

# Multimodal Recording of Historic Coins. Worth the effort?



Anna Bentkowska-Kafel, Eryk Bunsch, Miroslav Hain,  
Mona Hess, Lindsay MacDonald Aurore Mathys,  
Julio M. del Hoyo Melendez, Vera Moitinho de Almeida,  
Dirk Rieke-Zapp, Robert Sitnik and Jaroslav Valach

## Abstract

- This presentation illustrates the final report on an **exploratory study of Roman silver denarii conducted between 2014 and 2016** by a group of COSCH researchers working for scientific, academic and cultural institutions across Europe. A summary evaluation of approaches to multimodal recording will be offered. Scientific and museological questions to do with methods of technical examination, conservation, documentation and presentation of historic coins guided this research. An exhaustive list of questions can be found in the final report and on [a dedicated website](#).
- **Several non-invasive optical metrological, imaging and analytical techniques** were applied to silver denarii of Diva Faustina from two different editions. The use of the same objects throughout the tests enabled meaningful comparison of geometrical measurements and other results that will be presented independently.
- **The study has been informed by earlier research**, including: propositions for the development of relevant methods for recording historic coins in 3D (see Zambanini, M. Schlapke, M. Kampel and A. Müller, 2009, for an overview); applications of Reflectance Transformation Imaging (RTI) to numismatics (M. Mudge, C. Schroer et al., 2005 and 2012); metallographic examination of chemical composition of Roman coins using optical and scanning electron microscopy (SEM-EDS) (M. Ponting and K. Butcher, ongoing since 2014).
- **The question of adoption of advanced digital technologies in museum practice will be highlighted.** Based on the input into this COSCH study from leading coin experts, namely numismatists and metal conservators, we ask whether modern optical recording technologies are ready to supersede traditional photography as the main tool for the study and documentation of historic coins. The identified value of the COSCH study will be presented, alongside its main issues, pointing towards possible solutions.

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  - Meeting the objectives set out by the COST Transdomain Action "COSCH"
  - Addressing COSCH Primary Tasks (PT) and sub-tasks (st) (see COSCH [MoU](#))
- Cultural heritage (historic coins): research questions addressed
- Optical technologies: recording techniques used, with justification
- How has technology been used?
  - Acquisition
  - Processing
  - Constraints concerning measurements, processing, realisation of work
- How did the recorded data support the cultural heritage tasks?
  - relevant (characteristics of) content, which is inevitable to answer CH question
  - identified factors having impact on the content
  - measures to be taken helping to assure required content
- What are the technical limitations and reasons of errors?
- What are the benefits of the recording technique(s)/method(s)/data in comparison to traditional methods?
- Presentation and communication of the study and its outcomes

# Meeting the objectives set out by the COST Transdomain Action COSCH

• To realise an **interdisciplinary cooperation**, on a concerted European level, to prepare a novel, reliable, independent and global KNOWLEDGE BASE facilitating the use of today's and future optical measuring techniques in documentation of European CH.

- |                             |                    |                   |
|-----------------------------|--------------------|-------------------|
| • Archaeology               | • Computer science | • Data processing |
| • Art history               | • Physics          | • Visualisation   |
| • Conservation              | • Engineering      | • Semantics       |
| • Museology                 | • Chemistry        | • Web design      |
| • Documentation & archiving | • Photonics        | • etc             |
| • Photography and imaging   | • Metrology        |                   |

Each discipline has different motives for research, methods of investigation, measures of quality, metrics for assessment, means of documentation and metadata standards.

The goal was to reduce the knowledge gap by facilitating effective communication between the stakeholders.

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- Photography
- RTI & MiniDome (PTM)
- Depth sensing
- Photostacking
- Photogrammetry/Structure from Motion (SfM)
- Structured light scanning
- Laser scanning
- Photometric stereo
- X-ray fluorescence (XRF) spectrometry
- Scanning electron microscopy (SEM) with energy-dispersive X-ray analysis (EDX)
- X-ray microtomography (microCT)



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## TEST COINS

### Coin A – Aeternitas

Height 16.96 mm, Width 17.80 mm  
Disc thickness 1.51 mm, max 2.41 mm  
Perimeter length = 50.3 mm  
Area = 232.9 mm<sup>2</sup>  
Weight 3.11 g



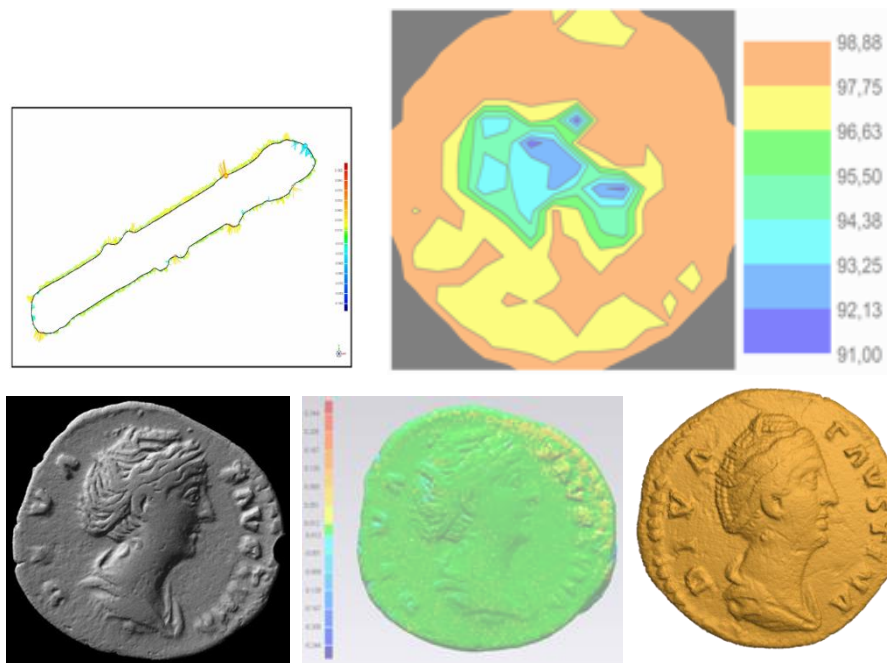
### Coin B – Vesta

Height 16.87 mm, Width 17.67 mm  
Disc thickness 1.44 mm, max 2.33 mm  
Perimeter length = 47.6 mm  
Area = 220.6 mm<sup>2</sup>  
Weight 2.85 g

RTI (© Lindsay MacDonald, UCL).

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## CURRENT DOCUMENTATION PRACTICE

Obverse: Bust of Faustina I, diademed, draped, right.  
DIVAFAV STINA  
Reverse: Draped female (Venus?) standing left.  
AVG V STA

Provenance  
By 1953: with Münzen und Medaillen A.G., Malzgasse 25, Basel, Switzerland (Münzen und Medaillen A.G. auction 12, June 11-13, 1953, lot 815); purchased by MFA from Münzen und Medaillen A.G., September 10, 1953, \$ 257.33

Credit Line  
Theodora Wilbour Fund in memory of Zoë Wilbour

Museum of Fine Arts, Boston



- Addressing COSCH primary tasks and sub-tasks through **RECOMMENDATIONS** for solution providers and end users
  - *Recommendations to facilitate deeper integration of optical technology into CH applications through an improved correlation between optical means and requirements (MoU)*
  - *The Action aims at the **foundation** of a structure that will become a reference for technical questions **related to cultural heritage studies** and 3D reproduction.*
  - *This interdisciplinary Action will bridge the humanities with the optical and information sciences. 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**.*
  - *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.*
- See **COSCH MoU** for further details.

## Cultural heritage (historic coins): research questions addressed

The study started with the questions concerning:

- The **authenticity and dating** of the test coins
  - Are the test coins authentic?
  - What **properties of the coins** evidence their ancient provenance / minting in Rome?
  - Are the coins contemporary to the ruler portrayed?
- **Comparison of features** of two, or more, objects of the same type



Focus stacking, © A. Mathys

- Suitability and **effectiveness of selected technologies** available to provide answers and feasibility of their wider **use in museum documentation practice**.

A wide range of other research questions inherent to the study and conservation of material CH – legal and ethical, historical, artistic, technological and scientific – have been addressed, *an exhaustive list at* <https://coschromancoins.wordpress.com/home-2/research-questions/>

## Optical technologies: recording techniques used, with justification

X-ray Micro - Computed Tomography is a non-destructive method for visualisation of internal micro-structure of small 3D objects - *in case of coins some cracks were detected*



In this study X-ray microCT was used for:

- *getting a look inside the object – coin under study,*
- *study of underlying roots of visual defects,*
- *detection – visualisation of invisible defects,*
- *corrosion phenomena study,*
- *addressing the issue of authenticity of the coins under study*

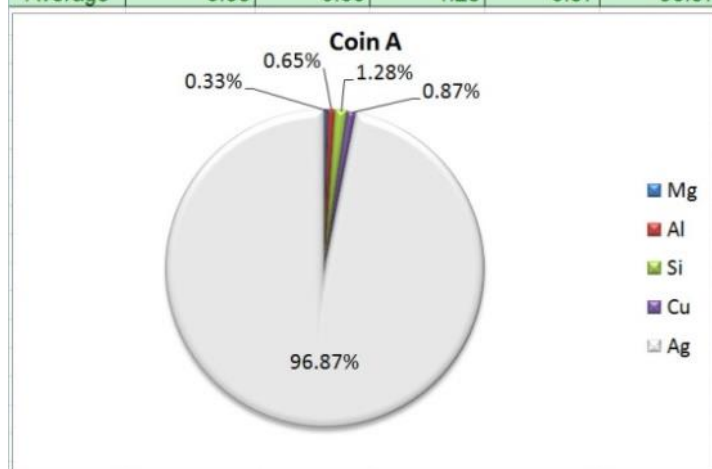
(© Miroslav Hain, Institute of Measurement Science, SAS, Bratislava)

# Optical technologies: recording techniques used, with justification

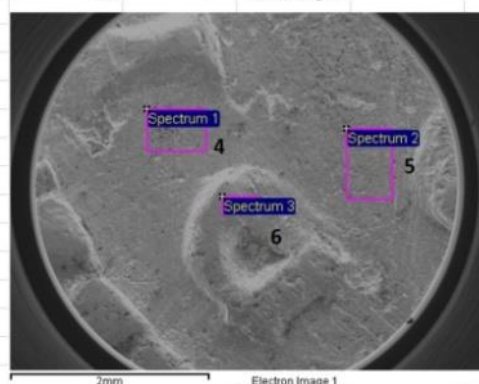
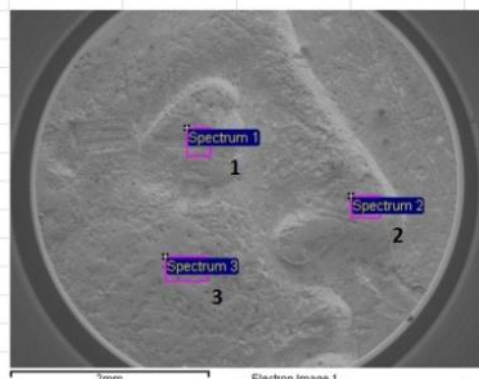
Scanning electron microscopy with energy-dispersive X-ray analysis (SEM/EDX) was used for studying the surface topography and chemical composition.

Coin A - elemental analysis (EDS)

Meas area No	Magnesium Mg	Aluminium Al	Silicon Si	Copper Cu	Silver Ag
1	0.37	0.84	0.89	0.39	97.52
2	0.27	0.88	0.77	1.25	96.83
3	0.31	0.52	1.1	1.13	96.94
4	0.37	0.78	2.38	0.71	95.75
5	0.37	0.52	1.37	0.51	97.23
6	0.31	0.37	1.15	1.23	96.94
Average	0.33	0.65	1.28	0.87	96.87



results in weight %



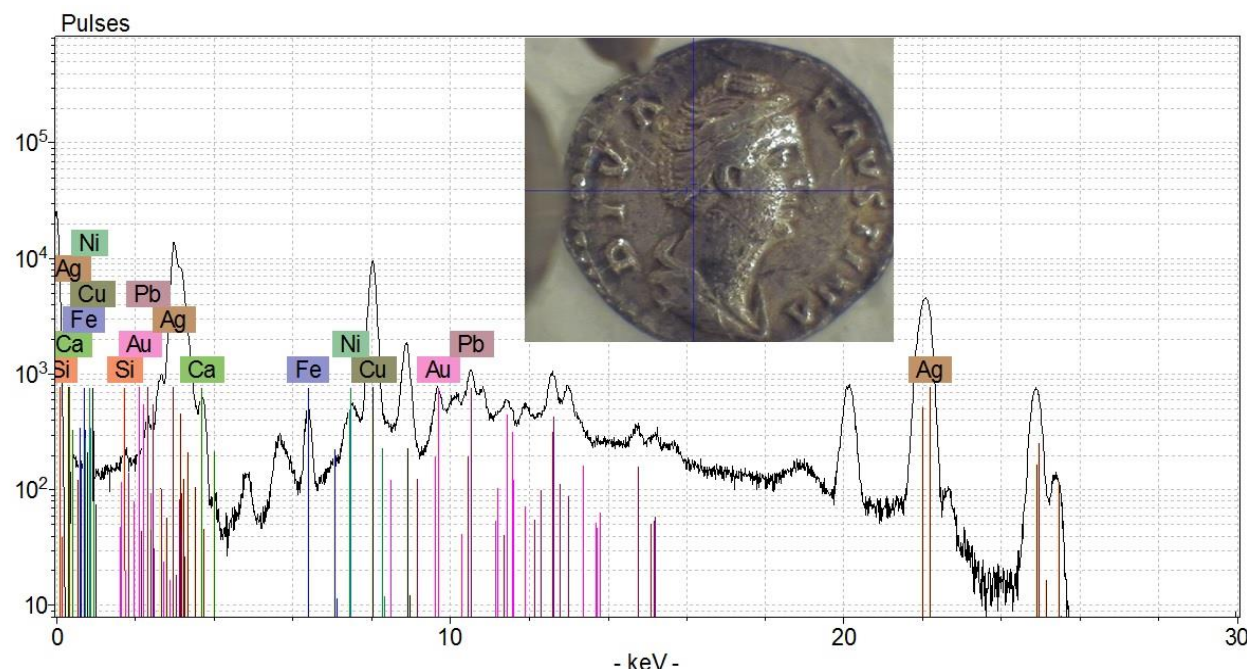
In this study EDX was used for:

- *elemental analysis of coins,*
- *determination of silver content and trace metals,*
- *addressing the issue of authenticity of the coins.*

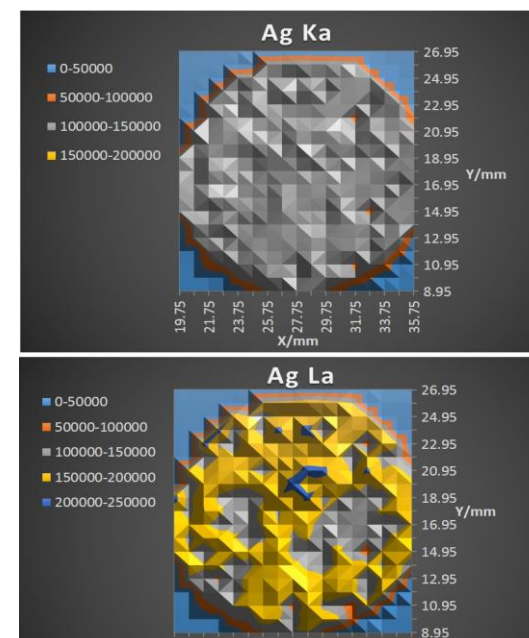
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# Optical technologies: recording techniques used, with justification



(© Julio del Hoyo Melendez, National Museum in Kraków)

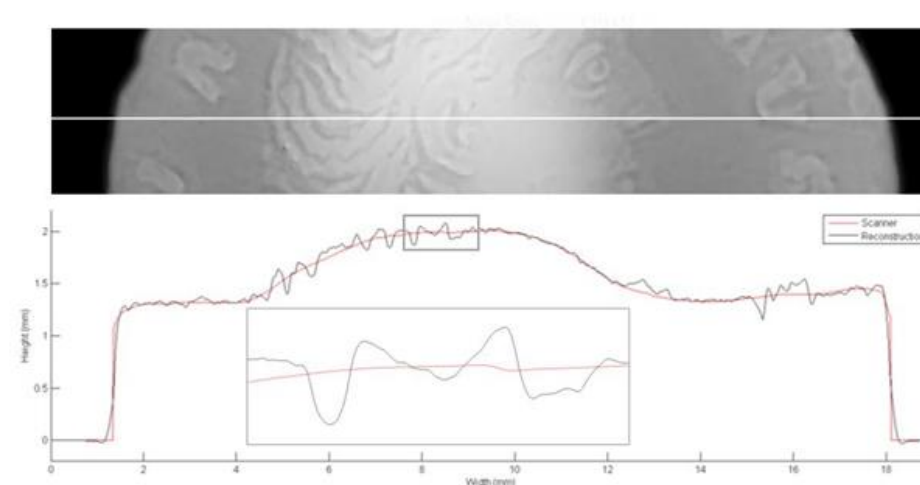
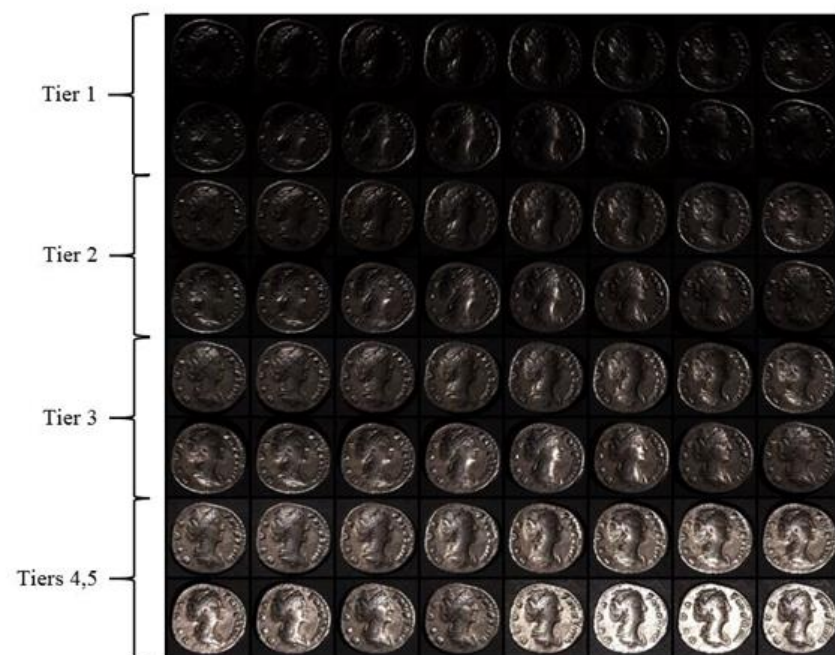


X-ray fluorescence mapping was applied to study the composition of the coins.

X-ray fluorescence arising from the surface of the coin was examined by spectral analysis for quantitative determination of silver, copper, and lead.



# Optical technologies: recording techniques used, with justification



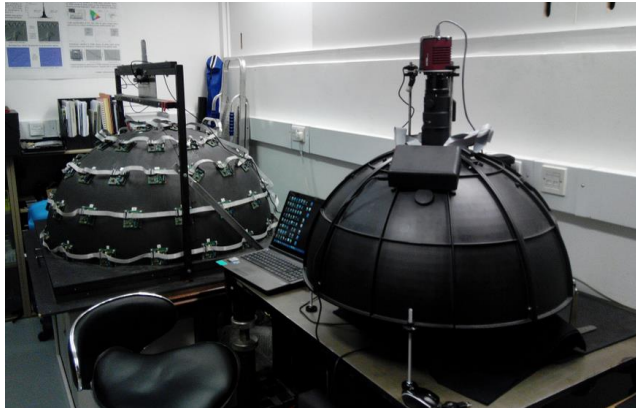
Photometric stereo - To increase the spatial resolution of the 3D digital representation of coins, fine photometric detail derived from a set of photographic images under the PTM dome (top) was combined with accurate geometric data from a 3D laser scanner (top right image, spatial resolution of 0.1mm).

The combined result (right) had a GSD/ Spatial resolution of 0.013mm or 75 pixels/ mm (right).



(images Lindsay MacDonald, UCL)

# Optical technologies: recording techniques used, with justification



Polynomial Texture Mapping (PTM) is one of a family of methods known as Reflectance Transform Imaging (RTI). RTI provides several advantages for near-flat surfaces:

- inexpensive and widely available and easily transportable hardware (SLR camera, tripod and flash);
- scales well for both small and large object dimensions
- can achieve a high sampling density for near-flat surfaces that is only recently achieved by other 3D imaging techniques and produces a highly detailed, colorimetrically correct, visually attractive and intuitively understandable digital image of the surface of an artefact.

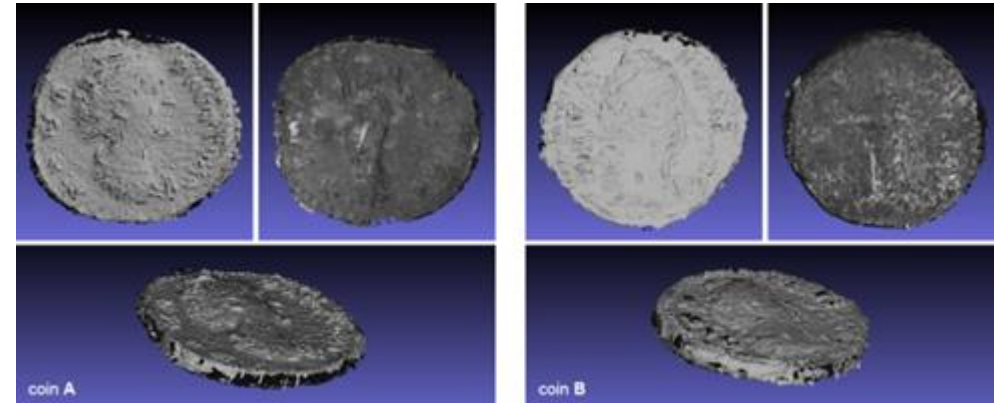




# Optical technologies: recording techniques used, with justification



Coin A (left), Coin B (right), Arius Technology 3D colour laser scanning with Identik300L. Colour not calibrated. GSD/ spatial resolution : 0.1 mm x 0.1 mm grid. (@UCL, Mona Hess)



3D models of coins A (left; clockwise: obverse, awers and oblique views) and B (right; clockwise: obverse, awers and oblique views) acquired with the *NextEngine* laser scanner, at Cyl. Rendering in *Meshlab*.

3D laser scanning has been applied to record spatial information, and at UCL simultaneously colour information. 3D laser scanning is increasingly used in cultural heritage and conservation for digital documentation and to record minute three-dimensional changes with high spatial accuracy and for measurements.

The resulting dataset can be a detailed metric 3D record of the object surface in-the-round and can also be used for morphological analysis and dimensional monitoring over time.

## Optical technologies: recording techniques used, with justification



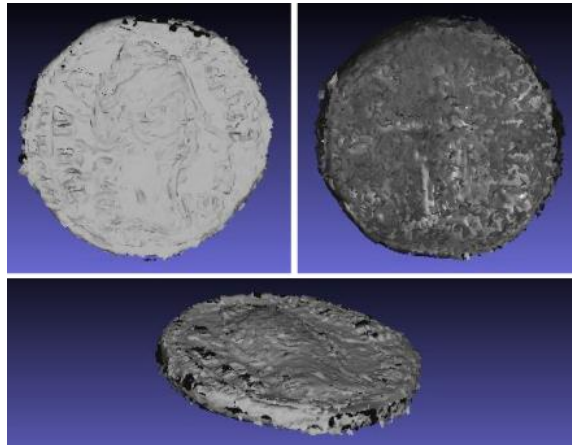
Focus stacking, © A. Mathys

Focus stacking was used in order to obtain a picture of the coin with extended focus in order to record the sharpest details.

# Optical technologies: recording techniques used, with justification

A number of 3D techniques were applied to measure and record the form and shape of the coins

## Laser scanning



NextEngine (© Cyl).

## Structured light scanning



Mechscan (© Aurore Mathys, RBINS).

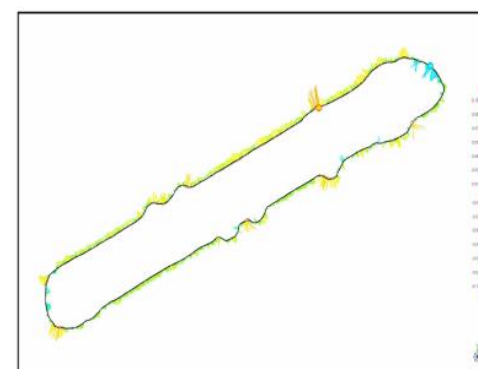
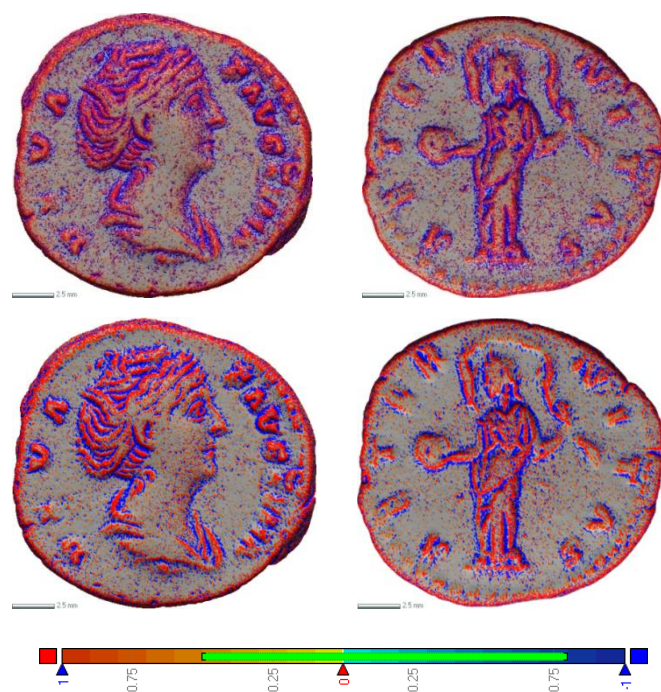


SmartSCAN HE (© AICON).



# Optical technologies

## Comparison of 3D digital surface models



This section is presented independently in:

"On the study of 3D digital models of historical silver coins: an integrated approach", by Vera Moitinho de Almeida.

## How has technology been used?

For each technology applied in the coin study information has been provided on

*SF as an example*

- **Acquisition:**

Mechscan + Flexscan  
Automated turntable

- **Processing:**

Standard processing (no smoothing or hole filling)

- **Constraints** concerning measurements, processing, execution of work

Scanner must be in a dark environment with stables condition

Objects cannot be too reflective or translucent or they will need to be coated  
(always ask conservator before coating an object)

- **Additionally:** pre-scanning treatment of coins



Mechscan (© Aurore Mathys, RBINS).

## What are the technical limitations and reasons of errors?

- For the comparison we have no ground truth data about colour and geometry
- Differences between instrument specification
- Different conditions of measurements could produce different output from measurements
- Lack of standards for recording procedures, verification
- It is very challenging task to compare results from different techniques
- Non-destructive XRF and EDS analysis are limited to the surface of an object due to their low penetration depth.
- Destructive analysis can sometimes give more information, but are not easy to justify in the CH field.

# What are the benefits of the recording technique(s)/method(s)/data in comparison to traditional methods?

- High-res photography and 2.5/3D imaging v. a traditional photographic record
  - Enabling more detailed studies
  - Ability to record an object all round; replicate
  - Linking/aggregating with other digital data
  - Ability to track changes through time (aging monitoring)
  - Further interdisciplinary applications
- Identification of the object material and its properties
  - Traditional: silver coin v. atomic inner composition and XRF surface analysis

## Presentation and communication of the study and its outcomes

•COSCH requirement: to communicate the work in a fundamental, transferable and understandable way. Ideally, the audience (present at the conference or having access later on to the presentations and reports) should be able to directly draw conclusions for their own work.

- Peer communication and evaluation
  - Coin study team meetings
  - Dedicated STSMs
  - COSCH meetings
  - Direct targeted communication, by email and face to face
  - The Day of Denarii, University College London, 22 June 2016, with invited expert numismatists and metal conservators
  - Publications: conference papers, STSM reports, Arqueologica 2.0 presentation, Conference Computer Applications and Quantitative Methods in Archaeology, JEI Journal paper (Journal of Electronic Imaging), SEAHA conference/ Journal of Heritage Science,
- Public
  - Website <https://coschromancoins.wordpress.com>
  - Forthcoming book chapter



# Presentation and communication of the study and its outcomes

## •On interdisciplinarity

The study engaged numerous disciplines.

Differences between culture and technology, and between motifs, methods and measures of quality between disciplines have been recognised.

The disciplinary specialisms and nuances in research interests, practice and individual needs tend to be underestimated in projects which involve applications of technology to arts and humanities studies.

## •On the benefits of the recording technique(s)/method(s)/data used in comparison to traditional methods

These should not be taken for granted. They need to be demonstrated and argued for.

Arts and Humanities have little interest in and knowledge of technology and are not convinced nor prepared to routinely rely on specialist technologies. Much more exposure to technology is needed; explanation is required how scientific data can or should be interpreted.

The museum is an interdisciplinary forum sympathetic to heritage science where this communication and education has a chance to make progress.

Aspects of scientific examination and technologies used may included in museum displays.

# Presentation and communication of the study and its outcomes

## •On labour and time involved and the cost of instruments used

These have been estimated for selected techniques, in selected labs.

E.g., when X-ray fluorescence mapping was applied to study the surface of the two test coins, a total acquisition time of 21 hours was needed to obtain 255 measurements of an area of 378.5 mm<sup>2</sup>. The quality of measurements depends, inter alia, on the cost of equipment, which may be extortionate for heritage institutions. These factors must be considered when advocating wider uptake of specialist technologies, preparing guidelines and recommendations for users.

## •On the value of the study

- The scope and complexity of interdisciplinary collaborative research
- Exposing the potential and issues
- Consistent use of the same objects
- Comparison of results between several applications of the same technology under different set ups
- Comparison of results achieved through applications of different technologies serving the same type of recording
- Open access to instructions and data sets

# Contributors to the COSCH Coin Study

**Anna Bentkowska-Kafel**, COSCH Vice-Chairman, [anna.bentkowska@kcl.ac.uk](mailto:anna.bentkowska@kcl.ac.uk)

**Eryk Bunsch**, Laboratory for 3D documentation, Documentation Department, Museum of King Jan III's Palace at Wilanów, K. St. Potockiego 10/16, 02-958 Warszawa, Poland.  
[jerzywart@yahoo.de](mailto:jerzywart@yahoo.de)

**Miroslav Hain**, Department of Optoelectronic Measuring Methods, Institute of Measurement Science, Slovak Academy of Sciences, Dubravska cesta 9, 84105 Bratislava, Slovakia.  
[miroslav.hain@savba.sk](mailto:miroslav.hain@savba.sk)

**Mona Hess**, Civil, Environmental and Geomatic Engineering, Faculty of Engineering Science, University College London, Gower Street, London WC1E 6BT, UK.  
[m.hess@ucl.ac.uk](mailto:m.hess@ucl.ac.uk)

**Lindsay MacDonald**, Research Fellow, Dept of Civil, Environmental and Geomatic Engineering, University College London, Gower Street, London WC1E 6BT, UK.  
[ucfslwm@ucl.ac.uk](mailto:ucfslwm@ucl.ac.uk)

**Aurore Mathys**, Scientific Heritage, Royal Belgian Museum of Natural Sciences, Rue Vautier 29, 1000 Brussels, Belgium. Collection Management, Royal Museum of Central Africa, Leuvensesteenweg 13, 3080 Tervuren, Belgium. [aurore.mathys@africamuseum.be](mailto:aurore.mathys@africamuseum.be)

# Contributors to the COSCH Coin Study

**Julio M. del Hoyo Melendez**, Research Scientist, Laboratory of Analysis and Non-Destructive Investigation of Heritage Objects, ul. Pilsudskiego 14, Kraków, 31-109 Poland.

[jdelhoyo@muzeum.krakow.pl](mailto:jdelhoyo@muzeum.krakow.pl)

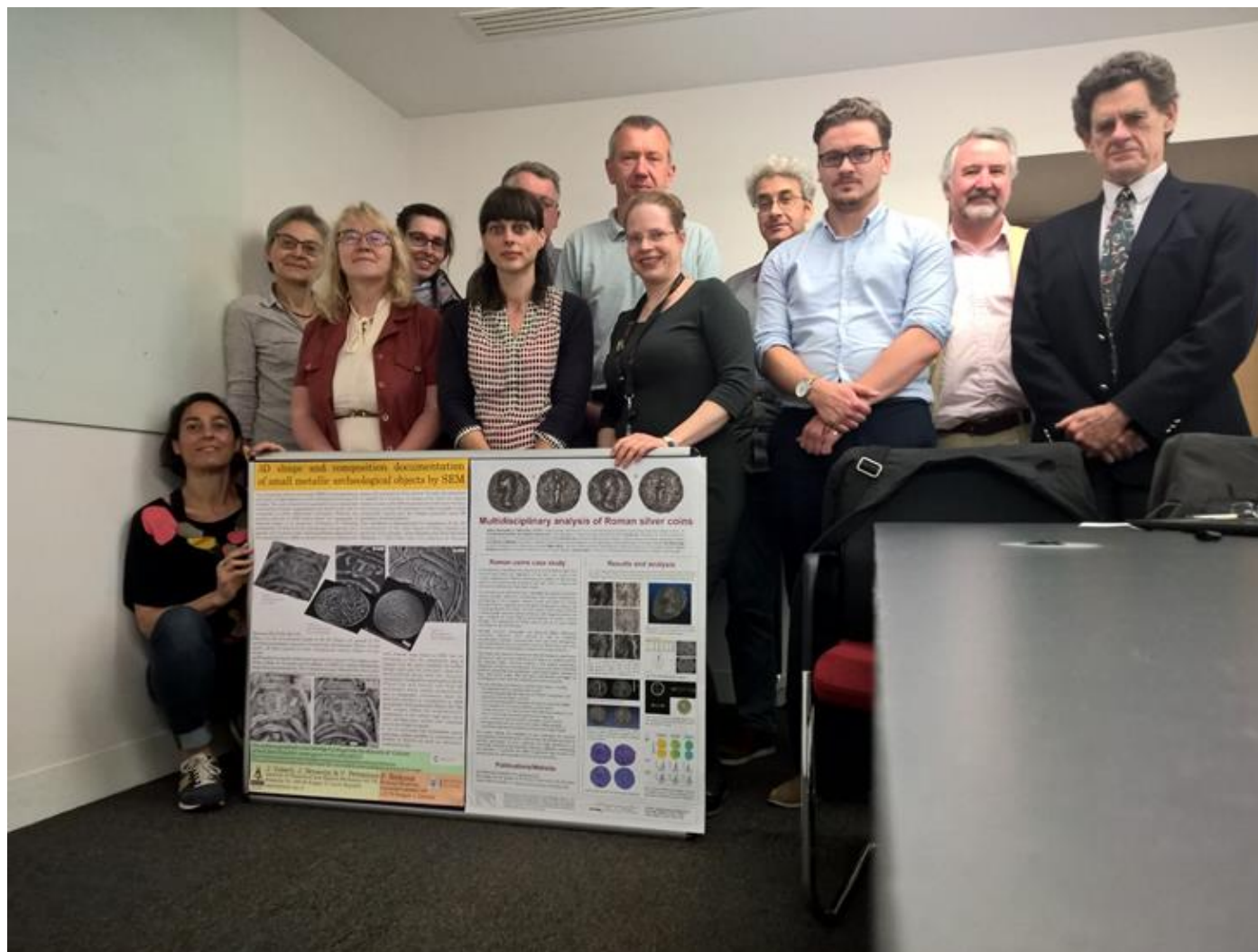
**Vera Moitinho de Almeida**, Postdoctoral Researcher, formerly at The Cyprus Institute, Cyprus. [veramoitinho@gmail.com](mailto:veramoitinho@gmail.com)

**Dirk Rieke-Zapp**, Business Field Manager Cultural Heritage, AICON 3D Systems GmbH (formerly Breuckmann GmbH), Torenstraße 14, D-88709 Meersburg, Germany. [dirk.rieke-zapp@aicon.de](mailto:dirk.rieke-zapp@aicon.de)

**Robert Sitnik**, Institute of Micromechanics and Photonics, Faculty of Mechatronics, Warsaw University of Technology, Poland. [r.sitnik@mchtr.pw.edu.pl](mailto:r.sitnik@mchtr.pw.edu.pl)

**Jaroslav Valach**, Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic, Prosecka 76, 190 00 Prague 9, Czech Republic. [valach@itam.cas.cz](mailto:valach@itam.cas.cz)

# Contributors to the COSCH Coin Study





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More information at  
[www.cosch.info](http://www.cosch.info) & <https://coschromancoins.wordpress.com/>