COSCH\textsuperscript{KR} ontology – the basis for a platform recommending 3D and spectral digitisation strategies

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Motivation

- Digital documentation of CH objects is an interdisciplinary task of CH-, spatial/spectral recording-, IT-, and visualisation experts.
- Which digitisation strategy is best suitable depends on the
  - CH application (= data usage)
  - CH object parameters (e.g., appearance, size)
  - Digitisation device and method (e.g., measurement principles)
  - Data processing (e.g., registration)
- content & quality of digital representations vary

Roman vessel
(385-400 AD),
8.3 m long
Dependency in between of characteristics: resolution and accuracy

Context: documentation of a Roman ship wreck

Terrestrial Laser Scanning vs. Images (Structure from Motion)

Resolution: lower - higher
Dependency in between of characteristics: resolution and accuracy

Context: documentation of a Roman ship wreck

<table>
<thead>
<tr>
<th>Terrestrial Laser Scanning</th>
<th>vs.</th>
<th>Images (Structure from Motion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global accuracy:</td>
<td>higher</td>
<td>lower</td>
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Asking only for high-quality data is not enough! Which recording strategy is suitable depends on the CH object, CH application, the capabilities of the recording device, and the data processing.
Motivation

• Bridge the gap between the various experts involved in the digitisation of CH objects through a platform under development which will give recommendations for recording strategies based on the information about the CH object and the intended data usage.

• COST Action TD1201: Colour and Space in Cultural Heritage (COSCH) provided the opportunity. It is a multidisciplinary European network of humanists, conservators, and engineers.
Idea

COSCH develops a web based system so-called COSCH Knowledge Representation Application (COSCHKR App)

- A user of this web based system would need to provide information about a CH object s/he would like to record, related external influences, and the intended application of the digital data.

- Based on the user’s input the platform will give recommendations which recording strategy is best suited to fulfil all input requirements.
Idea

• CH experts will benefit from this web based system as they will receive objective recommendations which s/he could use asking technical experts for specific offers.

• Technical experts will benefit from this web based system as they will receive more specific requests from CH experts. Furthermore, they could check their own approaches.
What is COSCH^{KR}?

What is needed to create such a web based system?

- We have to develop an ontology knowledge model (so-called COSCH^{Knowledge Representation}).
- This ontology structures all necessary knowledge about all decisive factors in the decision making how a physical thing (= CH object) has to be recorded to best fulfil the conditions of the targeted application.
- The web based system will use this ontology knowledge model.

The ontology is expressed in Web Ontology Language (OWL).
Strategy

- What do we need to do to create the COSCH\textsuperscript{KR} ontology?
  - We have to determine the scientific disciplines involved in spatial and spectral recording of CH objects: spectral recording experts, spatial recording experts, CH experts, IT experts.
  - We have to \textbf{structure the knowledge} (define a theoretical superstructure from experiences and empirical data)
    - Starting with the domain specific knowledge and then
    - relate the structured knowledge to each other
Strategy

• Background and basis is the fact that a deterministic relation exists between
  – the requirements of a CH application on spatial, spectral, and visual digital information of a CH object which itself has concrete physical characteristics, and
  – the technical possibilities of the spectral and spatial recording devices.

• We are developing a domain ontology.
  – It is a schematic model that will be used to infer recommendations at the schema level.
  – It will express a theoretical concept about the decision making of a technical expert choosing the best suitable spatial or spectral recording strategy.
What do we need to do to create the COSCH\textsuperscript{KR} ontology?

- Imagine the ontology being a tree
  - with a trunk
  - and many deliquescenting branches.
  - From branch point to branch point the description of a topic is getting more and more detailed.

- We have to create such a tree \(\rightarrow\) each branch at a time
• How to structure the knowledge?

1) Most important to create a consistent hierarchical structure are discussions:
   
   1) These discussions focus on specific CH Applications making it more easy for all partners:
      
      1) Spatial Case Study
      2) Spectral Case Study

2) It was decided to create five main branches: Physical Thing, CH Applications, External Influences, Technologies, Data.

3) E.g. the branch Technologies was split into:
Strategy

Most important are the rules and dependencies which link the five top-level classes and sub-classes.
Strategy

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Simulation of a GUI

- Spatial Case Study: Deformation analysis
  - Creation of 3D-models of waterlogged wood to determine and visualise the spatial differences before and after conservation treatment.
CH Object Condition
- Fragile, Moderately Rigid, Highly Rigid

CH Object Shape
- Cubic, Rectangular, Oval, Circular, Square

CH Object Size
- Small, Moderate, Big

CH Object Quantity
- Small, Moderate, Large

CH Object Reflectivity
- Low, Moderate, High

Texture
- Textured, Non-Textured

3D Shape

CH Application
- Deformation analysis
- Visualisation
- .................

Required Data
- 1D, 2D, 2.5D, 3D

Required Quality
- Low, Medium, High

has CH Application Demand of
CH Object Condition
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CH Application
- Deformation analysis, Visualisation

Technologies
- Technical Process
- Laser scanning, Struct. Light Scanning, Struct. from Motion

CONFLICT
- Generates Low Accuracy

has CH Characteristics of
has CH Application of
has CH Application Demand of

is a
is Suitable for Objects with
represents the shape of the CH object
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Deformation analysis
Visualisation

CH Application

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- **CH Object Reflectivity**
  - **Low**, Moderate, High

- **Texture**
  - Textured, **Non-Textured**

- **Budget**
  - Not Relevant

- **Technical Competence Needed**
  - **Low**, Medium, High

- **CH Object Application**
  - Deformation analysis
  - Visualisation

- **Markers**
  - Internal, **External**, Natural

- **3D Shape**

- **Workflow Method**
  - Automated, Semi-Automated, Manual

- **Technologies**
  - Technical Process
  - Laser scanning
  - Struct. Light Scanning
  - Struct. from Motion

- **Required Data**
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External Influence (Project)

- **External Influence**

CH Object Characteristics of

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CH Object

- Condition: Fragile, Moderately Rigid, Highly Rigid

- Shape: Cubic, Rectangular, Oval, Circular, Square

- Size: Small, Moderate, Big

- Quantity: Small, Moderate, Large

- Reflectivity: Low, Moderate, High

- Texture: Textured, Non-Textured

Budget

- Not Relevant

Technical Competence Needed

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CH Application

- Deformation analysis
- Visualisation

Markers

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- Budget Relevant

Workflow Method

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Required Data

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Required Quality

- Low, Medium, High

Markers can fix Internal Markers?

Respond: YES

Represented by the shape of the CH object

CH Characteristics of

has Generation of

has CH Application Demand of
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Required Generation
- Markers

Members

Deformation analysis

Visualisation

...
Status quo and future perspective

- CH Applications „deformation analysis“ (spatial) and „revelation of underdrawing“ (spectral) operable through the created ontology
  - more than 750 classes
  - Laser Scanning is partially included as an alternative approach
- Another spectral CH Application will be designed (Tatiana PhD topic)
- Further CH Applications will be implemented (even after COSCH)
- Ontology will be published in the near future through a front end using a **Prolog Inference Mechanism**
Prolog Inference Mechanism

- Under development in collaboration with MISANU colleagues from Belgrade
- COSCH\(^{KR}\) ontology is parsed to infer and discover knowledge for optimal recommendations
- A web service will be developed with an interactive interface (front-end) and COSCH\(^{KR}\) + inference mechanism (back-end)
Challenges

• Common understanding:
  – interdisciplinary understanding
  – remote discussions versus face-to-face discussions

• Discipline habits/methods have to be broken down into logically linked pieces

• Every single piece has to be named, structured, and linked
  – Example: text > chapter > paragraph > phrase > word > letter
In a long-term perspective, the entire CH community will benefit from COSCH\textsuperscript{KR} platform as digitisation projects, which rely on COSCH\textsuperscript{KR} recommendations, will be more sustainable and durable.
Thank you for your attention!

Publications:


in preparation:

• A. Karmacharya, St. Wefers, Structuring spectral and spatial recording strategies of cultural heritage assets - Background, state of affairs, and future perspectives. COSCH final book.


planned:

• Semantic reasoning
• Spectral case study
Inference system through Prolog

- Ontologies
  - optimal tool for knowledge representation
  - represents **WHAT** on a subject and not **HOW**
- Example:
  - **Structured Light Scanning** is defined through Structured Light Scanner, data it generates, a setup and a data processing – this is **WHAT**
  - BUT there are OTHER number of ways Structured Light Scanning works and they are **HOWs**. These **HOWs** are encrypted in COSCH^{KR} within single classes through rules.
  - Prolog is versed in managing these situation based **HOWs**.