Linked Conservation Data: Driving Change in Documentation Practice

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Abstract

Documentation is a core task for conservators, allowing evaluation of past choices and providing an evidence base for reasoned decision-making for future practice. However, much of the documentation created is not shared with other conservators or broader audiences. During the Linked Conservation Data (LCD) project, we explored the potential of documentation practices known as Linked Data for conservation, inspired by practices in other domains including medical science and biology, as well as various openGLAM initiatives. As part of the project we developed: guidelines for harmonising disparate conservation terminologies; proposals for encoding different types of conservation data; a template for articulating policy in relation to conservation data; and a Linked Data pilot demonstrating the value of the approach. This work encourages institutions to begin sharing conservation records routinely, for use and re-use by other conservators. Adopting such a practice at large scale will provide an invaluable resource of conservation related information that can be used for decision-making and enable data analysis and statistical work with large samples in conservation. We present conclusions and lessons learned from the LCD pilot, including the: importance of structured records; role of documentation of conservation vocabularies; foundational work still needed for sharing records as Linked Data; and practicalities of implementing a Linked Data system for sharing conservation records. We conclude by outlining the role and responsibilities that professional bodies need to adopt towards this effort.

Keywords

Documentation, terminology, modelling, data

Introduction

Documentation can be considered as a defining activity for conservation, as opposed to restoration where documentation is not always a core task. It can be used for informing future practice and for evaluating past practice. Yet conservation documentation is invisible and there is no common digital space where conservators can examine records. Heritage organisations' websites rarely include information about conservation work. Although projects from a decade ago shared conservation records (National Gallery London 2007), these efforts have not been widely adopted. The Linked Conservation Data (LCD) project establishes the foundations for such sharing to become routine practice. It proposes Linked Open Data (LOD), a set of tools and practices recommended by the World Wide Web Consortium (W3C), for sharing records online

efficiently (Bizer et al. 2009). This paper describes the activities of the LCD project, following an introduction to the value of sharing records openly.

Why share?

Following experience from other domains (e.g., biology, meteorology and archaeology), the importance of sharing conservation records was articulated recently (Velios 2021) and can be summarised in these points:

- sharing observations accelerates research in conservation and improves conservation practice,
- publicly-funded conservation work should be made available to the public.

Activities which benefit from shared records include:

- understanding the history of materials and techniques;
- assessing new materials;
- identifying patterns of damage in relation to environment;
- identifying trends in conservation treatments;
- estimating the overall condition of collections.

It is noted that some data cannot be shared, as discussed in the section about the LCD Policy Template.

While non-expert audiences have engaged with conservation since the 1970s, new opportunities for information sharing have since been created. From 'open' laboratories (Heath 2009) to conservation in public galleries[1] and podcasts,[2] conservators now adopt innovative dissemination methods. Access to conservation documentation for the general public would align with such efforts.

The promise of Linked Data

Linked Data provides a pathway to share conservation documentation across institutions. It is a set of practices and tools for making data available on the Web as combined datasets. Such combination is also called "data integration", "data interoperability" or "data harmonisation", which mean that data can be used through multiple tools without reprocessing and reformatting. This allows data created for one purpose to be repurposed and combined with other data through querying without repeating the process in multiple databases.

Linked Data does not compete with or eliminate other ways of producing data. Other types of data creation and analysis (e.g., data mining or machine learning) can also be used. Conservation data may be stored in repositories accessible on the web outside the Linked Data framework. Linked Data builds on top of these efforts to publish new or existing data so that it can be integrated into one large repository which is the world wide web. Linked Data relies on *structured* data, i.e., data which is free of natural language syntax and often accessed within databases as forms. This includes metadata accompanying narrative reports. Unstructured data can

also be used with Linked Data. For example, a block of text from a conservation treatment report can be made available as Linked Data, then further examined with alternative methods (e.g., natural language processing techniques).

To produce records using Linked Data principles we must ensure that:

- the terminology used can be understood regardless of the background of the conservator;
- data are harmonised without imposing restrictions on documentation practice;
- conservators make informed decisions on the types of data to share.

Ideally, conservators will be able to search records of different detail, i.e., from high level metadata common across all conservation sub-domains (such as material and type of heritage item) to in-depth data specific to a conservation sub-domain (such as the sequencing of sewing in book conservation).

Project consortium and scope

The LCD Consortium organised working groups and workshops on terminology, data harmonisation (modelling) and data policy. To gain experience utilising Linked Data with conservation records, a separate working group worked on a Linked Data pilot. While this pilot focused on data from a common type of book conservation treatment, the methods employed and the resulting recommendations apply to conservation in general. The consortium considered a range of sample case studies spanning building conservation to archaeological conservation and modern and contemporary art conservation to conservation science. The technical expertise and infrastructure needed for implementing these recommendations is significant. As such, it is likely that small conservation organisations will find it difficult to adopt them. A solution to this could be infrastructure sharing, which has often resolved issues of access in the profession.

Adopting Linked Data at a scale that will produce benefits for the profession is a valid long-term goal, because it is based on mature technologies of the world wide web. While software used for conservation documentation such as proprietary databases may become obsolete or superseded, the stability of Linked Data will remain applicable to the web infrastructure in which institutions invest.

Project work

Terminology guidelines

Conservators have skills in describing collections, materials, and actions. Terminology is a critical part of such descriptions. In conservation, a term may mean different things depending on context. For example, used by an objects conservator working on a wood table, the meaning of *grain* differs from the same term applied by a book conservator to the orientation of paper in the textblock. Elsewhere a material may be described differently depending on the background and tradition of conservators: e.g., *alum tawed skin* may be called *alum leather*.

Conservators have developed vocabularies and glossaries through specific groups (BPG 2021) or for specific resource areas (IPI 2022). Some vocabularies are large and broad, for instance the *Conservation & Art Materials Encyclopedia Online* (CAMEO) contains over 10,000 entries (Museum of Fine Arts Boston 2021).

Humans can be skilled at using these vocabularies, but additional processing is needed for them to be queried with software tools. Following Linked Data principles, vocabularies can be published to be interoperable while maintaining diversity. Currently, few conservation vocabularies are available as Linked Data. A systematic effort to publish them is needed to allow their integration.

The Simple Knowledge Organisation System (SKOS) (Miles and Bechhofer 2009) allows vocabularies to be encoded as Linked Data. An important principle is that terms[3] used in documentation must point to a stable URI (uniform resource identifier), most commonly a URL. The URI provides an unambiguous space to define the term regardless of the word being used (e.g., for endbands we can use: *headbands* or *cabezadas* or *κεφαλάρια* to mean exactly the same thing). The term can be given a context by connecting corresponding URIs of other terms hierarchically (pointing to either broader or narrower terms, e.g., endbands to binding components) or to related terms (endbands to endbanding – the process required to produce an endband). If all mentions of endbands point to the same URI then one can retrieve meaningful results even if different words have been used. This allows conservators to use diverse, complex, and precise terminology while also making the terms available for machines to search. In the section on modelling, we adopt the same principle, where URIs are used as identifiers for other things, including for example, the relationships between terms.

The LCD Consortium held a workshop at Stanford in June 2019 to explore the current landscape of conservation terminology. Participants reviewed vocabularies and summarised the potential of each for Linked Data.[4]

Following the workshop, the LCD Terminology working group developed workflows to assist with sharing conservation vocabularies as SKOS Linked Data. The first workflow (Figure 1) evaluates a vocabulary and determines the processing required for its publication. Resources to assist this evaluation and to move the process forward are listed.

The second workflow (Figure 2) demonstrates how to align vocabularies. Alignment between vocabularies allows conservators to use different words for the same term and requires matching the terms across vocabularies. An efficient way of matching is through a ‘hub’ thesaurus such as the Getty Art and Architecture Thesaurus (AAT), which is already available as Linked Data and can act as a matching bridge.

Finally, LCD set up a GitHub repository[5] as a central location for conservation vocabularies that are available for use in Linked Data applications. GitHub is a platform used by software developers that also allows relevant resources, such as vocabularies, to be stored and shared. Further work will make these vocabularies available through a centralised user-facing portal, but additional funding would be needed to implement that.

Modelling

Linked Data represent relationships which are shown here using arrows [→]. For example, for a given treatment, a relationship connects isinglass with the treatment (isinglass → was employed in → treatment) and another relationship connects a pigment with the treatment (pigment → was modified by → treatment). Such statements are structured data. The relationships are standardised and *modelling* is the process of creating these statements. The patterns reflected in these statements specify what is known as an *ontology*. The ontology results in datasets that can be queried jointly based on these patterns. The LCD Consortium is using the conceptual reference model (CRM) maintained by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM), which is known as the CIDOC-CRM ontology (Doerr 2003).

Evaluation of the CIDOC-CRM

During a workshop held in London in September 2019, several examples of conservation documentation were contributed. These were modelled with the CIDOC-CRM and the following areas of improvement were identified for the ontology, which are currently being explored further:

- negative information, e.g., that an object is *not* made of a material, which is often significant when considering provenance and material evidence;
- planned activities, such as proposed treatment;
- presence of multiple things, e.g., a book with many leaf markers, allowing a description of the types of markers, without referring to each individually;
- risk, such as the potential for flood damage from heavy rainfall.

Landscape

The CIDOC-CRM allows different ways of modelling data. Some models already exist and these were reviewed to reveal any current preferences. The models reviewed were: CRMcr (Niang et al. 2017); CPM (Fiorani and Acierno 2017); and EAMENA (Zerbini 2018). Each was considered in relation to describing: past conservation activity; the effects of deterioration; measurements (i.e., anything that has a dimension); risk assessments; and the construction of material heritage. The main findings of the report (Moraitou and Christodoulou 2021:26)[6] indicate some overlap (e.g., risk assessment is central to CPM and EAMENA but does not feature in CRMcr), but also good coverage of the descriptions listed above. Based on this work we could envisage one model which is broadly applicable to conservation data.

Conservation core and sub-domains

To achieve interoperability, a model that can be implemented with limited resources and be applicable across the profession is needed: a conservation core model. During the LCD workshops, discussions around such a model took place, but further work is needed. Currently, we recommend that basic *typology* information for objects and components, materials (construction of material heritage), condition (the effects of deterioration) and treatment (past conservation

activity) are included. This implies that measurements and risk assessment are not included in such a core model, but further expansion is not restricted if it is deemed necessary.

Linked Data pilot

In the Autumn of 2019, partners from the Bodleian Library, Oxford; the Library of Congress; the National Archives (UK); and Stanford Libraries undertook a Linked Data pilot. Participants provided 30–50 conservation treatment reports spanning 40–50 years, all focused on a common book conservation treatment: reattaching detached boards.

In designing the pilot, the following research questions were posed:

- What is the history of board re-attachment techniques over the last 50 years?
- Can we identify the periods during which each repair material was used?
- How do detached boards relate to other book condition types (e.g., spine re-attachments/repairs)?

Two institutions provided structured data in spreadsheets, while data from others were transformed into structured data. Participating institutions formalised the terminology found in their documentation. They gave each term a unique identifier in the form of a URI, *and* pointed to external terms found in hub vocabularies such as the AAT.

Post-doctoral fellow Alberto Campagnolo and Ryan Lieu of Stanford Libraries modelled data using the CIDOC-CRM, producing Linked Data. For this, the encoding format chosen was the resource description framework or RDF (see Cyganiak et al. 2014:1). Each used different tools for the transformation showing that Linked Data can be produced in a variety of ways depending on the resources and expertise available in each institution. Integrating the resulting models to allow cross-searching required considerable effort. The modelling process (Campagnolo and Lieu forthcoming) involved an iterative process of testing queries corresponding to research questions based on modelled data, refining the model and repeating the exercise until all data were reflected in the resulting queries.

After modelling, the datasets and vocabularies were loaded into ResearchSpace,[7] a Linked Data platform developed by the British Museum. This provided a portal for users to access the datasets using templates provided by ResearchSpace. Query pages were created reflecting the pilot research questions and highlighting new narratives based on the combined datasets. An example for one of the research questions is given in Figure 3. The pilot implementation is available online.[8]

Policy template

The last strand of the project was the development of a policy template for conservation data. The objective was to engage in dialogue with institutions interested in supporting the community by sharing documentation records and offer an avenue for policy change. The policy template[9] provides a skeleton structure for producing data policies in conservation departments based on the following principles.

Principles

The policy features the following non-exclusive principles:

- Data are shared as openly as possible observing copyright rules, cultural ownership and excluding sensitive data.
- Data are shared after a period specified by the data producer to allow for any publications by the data producer to take place first.
- An attribution of the data producer is included with the shared data.
- Data are shared in an open format, i.e., a file format whose specification is freely available, allowing license-free software implementations (e.g., simple text-based formats such as CSV rather than manufacturer specific binary formats). This allows others to access shared data without purchasing expensive software or agreeing to prohibiting conditions of use.
- Vocabularies used to produce the data are shared with the data.

These principles align with the descriptions for 5-star open data[10] and with the FAIR data principles – Findable, Accessible, Interoperable, Reusable (Wilkinson et al. 2016). Formats used for Linked Data are almost always open both because they rely on simple text and because their specifications are freely available. The policy document has a broader scope and can be applied to other types of data, e.g. complex imaging data or data from analytical tools, which may be produced in proprietary formats that pose a barrier to potential users. It is important to consider data formats before purchasing analytical equipment. For legacy systems, where alternative formats are not possible, a process of data transformation may be needed. This may be resource intensive and could prevent conservators from sharing valuable data. Principles of sharing form the basis of research in many disciplines and harmonising data is part of an effort to encourage conservators to embrace these.

Ratification by professional bodies

The policy template has been developed after engaging with communities of conservators from three conservation professional bodies: the International Institute for Conservation (IIC), the American Institute of Conservation (AIC) and the Institute of Conservation in the UK (Icon). The last two represent the main conservation professional bodies from the two countries involved in the funding call under which the project was funded. Workshops with representative members of each professional body were held to improve on early drafts and the template is now considered mature. All three have endorsed the policy template as indicating good practice in the domain and institutions are considering adoption.

Conclusions

LCD explored how to make conservation documentation more shareable and accessible through Linked Open Data. Through workshops, meetings, and a pilot, we engaged with conservators, conservation scientists, data scientists, technical experts and academics with divergent types of conservation documentation. Working in the domains of conservation terminology,

data modelling with the CIDOC-CRM and policy development, we see the following areas that need continued development and attention.

Importance of structured records

Linked Data require conservation records as structured data. It is possible to create metadata that describe unstructured data, but processing those is time consuming and is unlikely to contain the level of detail possible from structured data. This is not to devalue unstructured records, but to provide a framework that enables unstructured records to be shared.

For systems with limited structured data support, it may not be possible to share detailed records as Linked Data. Sharing enough data to allow discovery would provide Linked Data pointers to records that are not available as Linked Data. For example, instead of converting a text about a binding structure into Linked Data, it may be possible to share a list of materials as Linked Data to allow interested users to discover the text after querying for materials. A Conservation Core model may help in this task.

Conservation vocabularies

LCD has established a framework for converting conservation vocabularies to SKOS Linked Data. Other projects are responding to this initiative, but further resources are needed to intensify this effort. We are working to produce a sustainable model of funding for establishing a long-term vocabularies platform that will act as a central point for integrating conservation vocabularies.

Modelling conservation data

Additional work on the CIDOC-CRM ontology for conservation has been identified:

- The ontology needs to be extended to represent risk and risk assessments, e.g., prioritisation of activities after a disaster contained in disaster plans.
- A simplified model for representing conservation documentation (we refer to it as Conservation Core) would make it easier to transform conservation data into Linked Data based on the CIDOC-CRM ontology.
- Given the variety of conservation disciplines, more specific profiles by area of practice could be developed to accommodate more detailed structured data outside the scope of Conservation Core.

Responsibilities of professional bodies

Finally, our professional organisations can play a key role in promoting good practice with data sharing through policy and training. Usable Linked Data should be developed after considering the implications for sharing data beyond the institution or conservation practice where they are created. Clear data policy guidance can help conservators and their administrators make appropriate choices. By endorsing good data policies, the professional bodies have raised the visibility

of these conversations and decisions, and we are pleased to have the support of IIC, AIC and Icon in this endeavour. Professional organisations can also support and promote educational opportunities for conservators to learn more about data practices, including Linked Data, so that both established and emerging professionals are ready to produce documentation designed to be shared.

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Notes

1. For example, *Project Blue Boy*. Accessed 1 April 2022. https://www.huntington.org/project-blue-boy.
2. For example, *The C Word*. Accessed 1 April 2022. https://thecword.show/.
3. Note that elsewhere 'terms' are also known as 'concepts'.
4. Accessed 1 April 2022. https://www.ligatus.org.uk/lcd/controlled-vocabularies.
5. Accessed 1 April 2022. https://github.com/linked-conservation-data/conservation-vocabularies.
6. Accessed 1 April 2022. https://www.ligatus.org.uk/lcd/output/248.
7. Accessed 1 April 2022. https://researchspace.org/.
8. Accessed 1 April 2022. https://lcd.researchspace.org.
9. Accessed 1 April 2022. https://www.ligatus.org.uk/lcd/output/216.
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Figure captions

Figure 1. Workflow for publishing vocabularies as SKOS Linked Data.

Figure 2. Workflow for aligning vocabularies with hub vocabularies.

Figure 3. Screenshot of the LCD pilot implementation with a graph depicting frequency of board reattachment techniques over time. Note that this query is based on a consistent model across datasets, but without the individual vocabularies having been aligned to shared URIs. As a result *slotting* and *board slotting* are correctly returned as techniques used during treatment, but they wrongly appear as separate entities.