

Paper: Managing Digital Image Repositories as Key Tools in the Preservation of Cultural Objects

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Abstract

A number of preservation efforts are currently under way to develop standardized digital repositories of images and information about cultural objects. At opposite ends of the size spectrum are the Fiber Reference Imaging Library and the World Trade Center Archive digital repositories. Both contain images on fragile objects, both in terms of structural integrity and vulnerability from exposure to uncontrolled environments. At the micro level, to address the needs of textile conservation and research efforts worldwide, the textile community has begun planning for the establishment of a digital repository of textile fibers, for search, access and retrieval by textile conservationists and scientists worldwide. With standardized metadata elements based on the Dublin Core metadata elements; this repository can provide important artifact information for a range of microscopic textile fibers. At the extreme macro level, the 9/11 archive includes an image and information repository of rusting steel columns, large complex composite structures, crushed vehicles, and the Last Column, the final steel support column with large amounts of ephemera attached, such as paper memorabilia, photos, and personal items. These digital repositories of cultural objects pose many digital management challenges, including: Metadata, content and rights management, access and retrieval.

Cultural Preservation Issues

The responsibility of preserving our cultural heritage requires careful monitoring of the state of the artifact, its deterioration and the commensurate environmental conditions. These heritage objects can range from light and fragile historic textiles such as national flags, to heavy and seemingly solid artifacts recovered after 9/11 in the World Trade Center (WTC) Archive. The range of objects and the demands of restoration pose significant challenges in establishing common metadata standards for the management of deterioration and preservation information. This information is critical to the ready search, access and retrieval of digital images used for assessments and monitoring, as well as comparative use for the preservation of other artifacts. Since artifacts inevitably deteriorate, these metadata elements must support a dynamic data set, with metadata and classification systems flexible enough to define and store information on the changing conditions and parameters.

Dynamic metadata and classification standards are needed to allow flexibility in recording changing conditions and deterioration over the life of an object. With common standards, these can be utilized by a range of scientists and conservators to determine optimum conditions for slowing the rate of deterioration. Critical metadata elements include risk factors and object specific location and display data.

Digital images for cultural objects includes categories of specific metadata about the risk associated with each object, which then dictates the conservation and preservation requirements. The

risk factors for each object are dependent upon regularly updated data from assessments of the changing state of the piece, and the potential availability, applicability and amount of research information about surface treatments. Well-defined object location metadata is critical to adequately assessing the archiving and/or display potential in response to numerous requests for object loans, based on the condition of the piece. Location categories include data about museum, indoor and outdoor environments.

Standardization of the image assessment of deterioration processes is essential and allows preservation digital image repositories to be used for comparative purposes as an integral resource and tool for preservation professionals. Image assessment parameters need to be carefully defined to ensure they accurately document deterioration processes relevant to the specific material and artifact, and can be used for comparative purposes on a similar artifact or material in the digital repository. The ability to track deterioration rates and processes with images and carefully managed metadata is critical for the usability of the preservation archive, as well as careful management of this dynamic digital image repository.

Rights management is also of particular concern for cultural heritage objects. Controlling access to images, data and digital repositories pertaining to the state of cultural artifacts is critical for collections management and protection of museum security. In addition, deterioration information is of great interest to those intent upon creating antique replicas and forgeries, and access to specific information should be monitored and restricted to specific groups committed to cultural preservation.

The establishment of preservation digital repositories for archiving, managing and accessing information about deterioration rates and processes requires common information standards for the sharing of critical preservation knowledge. While many cultural conservation digital repositories are concerned with documentation of objects, this effort focuses on effective management of digital repositories through the integration of images, object condition and deterioration information and environmental data. Effective digital image archiving allows museums worldwide to search, access, analyze, integrate, share and retrieve preservation information rapidly, to contribute to the preservation of cultural heritage.

Standardizing the Evaluation of Deterioration

Useful deterioration image information requires the accurate measurement and assessment of key object characteristics for effective archiving. Whether the object is a tiny fragile organic fiber or a huge seemingly robust metal beam, specific standardized attributes can be measured, imaged or recorded, and stored as data for access by users ranging from scientists and materials experts to conservators and curators. Whether the source artifact is the fabric of the Star Spangled Banner or the structure of the former Twin Towers, standardized data elements must be used to store identification and deterioration information. The development of a

fiber reference library and an archive of steel objects from the WTC are dependent on standardized metadata. Kebbell et al. note that “Institutions around the world are accumulating more and more digital objects. The task of managing these objects throughout their life cycle, especially for institutions tasked to preserve them in perpetuity, becomes more complex the more deeply it is investigated.” [1] Although museum standards such as AMICO are used to catalog museum objects, a common standard is required to record changes in the object and environmental conditions over time for cross-domain use by not only museum professionals, but also experts in other fields ranging from forensics to basic science [2].

The linkage of micro sampling object images with the “macro” of observations about the object itself is a critical part of analyzing and accurately assessing the object and its preservation requirements. Standardized metadata allows the tracking of dynamic changes associated with preservation conditions and risks from access, display, archiving, and movement of the object.

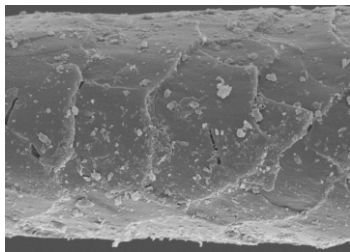


Figure 1. Aged Wool fiber Microfractures



Figure 2. Fissure Formation in WTC Steel Composite

As an example, since all materials exhibit fracture surfaces indicative of deterioration, images of both fibers and structural steel can be monitored to assess degradation changes. Recording the results of accurate assessments and analyses of these changes using standardized metadata is critical for preservation. A controlled vocabulary of deterioration is fundamental to assessing the mode of fracture, allowing the linkage of a fracture type with a specific cause [3].

Fiber Reference Imaging Standard

The mechanical properties of historic fibers reveal key information about the state of the textile and its degradation from environmental parameters and treatments. While subjective observations of historic textiles have traditionally been the basis for conservation evaluations, linking these assessments with objective analyses offers a more accurate reflection of the state of the textile.

A range of organizations participating in planning for the Fiber Reference Imaging Library (FRIL) have developed a metadata standard for a collaborative, public domain, web-based, textile fiber

digital reference archive. Images of specific textile fibers, including fiber reference information and associated metadata, will be accessible for a range of fibers to support conservation treatment, research, education and training by:

- Curators
- Conservators
- Scientists (Conservation, Textile, Forensic, Anthropology)
- Educators and Students
- Preservation Professionals

The FRIL Standards Committee, represented a range of organizations with expertise in textile and forensic science, conservation, information systems, systems integration, education, and textile collection management, has developed the initial draft of a metadata standard based on the Dublin Core Metadata Element Set, combined with additional image and textile metadata elements. This standard has been tested with exemplar fiber images and metadata entries provided by conference participants. Based on the exemplar input and further review and discussion, the committee has proposed a final draft FRIL Metadata Standard for review.

Metadata Standard Elements

The FRIL standard includes the following metadata categories, based on Dublin Core Metadata Elements and specific ontology relevant to the image and preservation archive [4]:

1. Image Identification Information

Basic information about the objects and images (the data set); domain must be in accordance with Dublin Core Metadata Element definitions.

2. Sample Reference Information

Details about the original object from which the data set is derived.

3. Imaging and Spectral Data Reference Information

Information describing the conditions used to acquire image objects.

4. Data Type Information

Information about the technical format and protocols for the images and data elements.

5. Object Description Information

Information about the textile and yarn from which the sample is derived.

6. Fiber Information

Information about the fiber morphology and any changes or deterioration of the fiber sample.

7. Metadata Reference Information

Information about the status of the metadata information, and the responsible party.

8. Metadata Extensions

Additional specialized elements needed by the metadata producer or user.

The Dublin Core Metadata Element Set provides the basic reference data sets, with Categories 1, 2, 4 and 5 as natural descriptors of the data or its basis, and Categories 3 and 6-8 indicating the specific extensions necessary to adequately address the requirements of dynamic preservation image analysis.

As noted by Toth “System controls for an imaging database are those elements that play a critical role in guiding and defining the scope and content of the database, as well as the utility of the data and information [5].” The effectiveness of any preservation image archive is dependent upon good metadata to ensure the data elements 1) address the range of users’ needs, and 2) encompass

those observations critical to the preservation and image analysis of the cultural objects.

Digital Image Objective Assessment

Digital image assessment is critical in providing objective measurement of changes that may otherwise not be discernable to the naked eye through subjective preservation assessments. For example: a much deteriorated textile may be subjectively assessed visually as having no changes in fading, losses, or other visual parameters. However, objective visual assessments may reveal CIE $L^*a^*b^*$ color measurement differences, both color shifts and fading. Furthermore, linking the image assessment to additional chemical and physical information integrates information that may indicate if mechanical strength is reduced. While this may not be apparent from a subjective handling assessment, the importance of this information relates to the proportional changes in the artifact. While a 1% strength loss may appear insignificant, for a textile that only retains 20% of its original strength, this is proportionately much greater than the 1% loss for this textile when at its original 100% strength.

Controlled Vocabulary

Integrating existing classification systems – in this case classification schemes for the textile item, fabric, yarn, and fiber types – is one of the challenges faced in defining deterioration and describing historic artifacts. Textiles are notoriously complex due to the wide range of substructures and base material – an item can be made from wool, silk, cotton, linen, metallic thread, or any combination of these fiber types.

Controlled vocabularies are used to describe image and data content and represent concepts by assigning terms of one or more words as metadata associated with objects [6]. A well-defined controlled vocabulary for each classification schema is imperative for a robust archive. The retrieval of comparative images is heavily dependent on the quality of the underlying vocabulary and thesauri that support the standard. "The effectiveness of searching can be significantly enhanced through the existence of rich consistent metadata." [7].

Metadata that has been well structured can facilitate the search for and integration of information, without compromising that quality of the resource. Linking the environmental conditions to the object also offers valuable conservation information about the state of the artifact. Table 1 gives examples of descriptors of fiber changes that can then be quantified through image analysis and measurement to establish levels of deterioration.

A further challenge with standardizing terminology is the use of substrate specific terms. While general features such as fiber fractures (as noted above) can be quantified, textile fibers present the additional complication of having inherently different features that can be measured or quantified through image analysis. For example: Wool fibers have an external layer of scales that can be measured through loss of size, thickness etc, and an aspect ratio dimensionally of an oval shape where flattening and loss of shape consistency can indicate deterioration; however, cotton fibers exist as long flattened twisted ribbon structures, so image analysis parameters change and the vocabulary used to accurately document these deterioration changes would need to be specific to each fiber type.

Table 1. Fiber Descriptors

Aspects of Fiber Deterioration
Fiber fractures (Fibrillar, Smooth, Shear, Concave)
Surface soiling (Particulates, Size, Amount)
Crushed / Flattening
Fibrillation
Broken distal ends

9/11 World Trade Center Archive

The WTC Archive contains a diverse range of objects retrieved from Ground Zero during the rescue and clean-up operations. The archive is unique for its immense and complex items, including 30-60 ton rusting steel columns and building sections, 15-30 ton composites of compressed building materials and office contents from a number of floors, crushed emergency vehicles, and the photo and paper covered "Last Column." These objects are both structurally and environmentally fragile.



Figure 3. Distorted WTC Steel Beam

The various types of materials are categorized and prioritized for treatment, storage and display by risk. This is assessed based on the inherent characteristics and condition of the object, as well as preservation requirements associated with storage and/or display conditions and environment.

As with most museum collections, much of the WTC Archive will remain in storage. This is a significant challenge for this collection due to the immense size and weight of so many unwieldy objects. A balanced and standardized set of metadata elements are needed to meet a range of requirements, including environmental conditions for storage and exhibition and condition and display potential based on fragility and treatment. Preservation images can be an effective tool in determining the best environment for an item and reducing the level of risk. The WTC Archive is developing a metadata standard to support a cross-section of users – from architects and structural engineers to curators, conservation scientists and conservators.



Figure 4. Vehicles in the WTC Archive

The size and difficulty of imaging large sections poses challenges – as with smaller artifacts – in accurately selecting a section to image and assess that represents the whole artifact. It may be more relevant with these very large items to assess and determine the various categories of deterioration overall. After determining the main causes of deterioration, i.e. changes in humidity, and the manifestations of these causes (such as fractures, rusting, loss of structural integrity etc) these changes can be tracked through image assessment in areas where the specific aspect of deterioration is changing most rapidly. In addition, precise mapping of the area identified for image assessment is critical to give a true and accurate assessment of the deterioration, and therefore an assessment of the effectiveness of preservation measures.

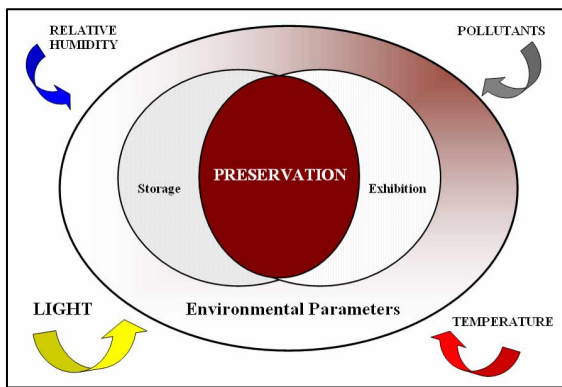


Figure 5. Effect of the Environment on Preservation

While AMICO has established fields for cataloging objects, it does not allow the flexibility of Dublin Core to create the required metadata schema for specific ontology relevant to the preservation archive. The difficulty in choosing the most appropriate standard is in selecting one with the flexibility to meet the broad needs of the archive. In this case, the metadata definitions must address the needs of the proposed 9/11 museum, while also meeting a range of preservation and loan requirements over the years. The use of metadata crosswalks (semantic mapping) will be critical for interoperability of the archive with others, especially for images collected from multiple sources.

Standardization of Categorization

Each category of images includes more specific metadata about the risk associated with each piece, which then dictates the conservation and preservation requirements. Well-defined metadata for object location is critical for tracking and moving objects. Metadata is also needed for material not going to museums to

adequately assess the possibilities for storage or display to meet the numerous requests for loans, based on the condition of the piece. Image assessment of artifacts in storage provides critical information about the efficacy and preservation aspects of the storage environment. Location categories include the following data about museum, indoor and outdoor environments:

- Outdoor monuments
 - open to weathering
 - some weathering protection
- Indoor controlled environment
 - some control
 - precisely controlled environmental specifications

The risk elements are dependent upon regularly updated data from image assessments of the changing state of the piece, and the potential availability, applicability and amount of research information about surface treatments. For example: Has the rust level stabilized or is it increasing? Have environmental changes increased the risk to the piece? Has the structural integrity decreased? Are significant markings at risk?

With the creation of microclimate areas for specific items in museum spaces, the level and control of relative humidity will be based on the fragility and risk of the object. Relative humidity fluctuations will increase the risk for the object because of its response to changes in moisture levels, which will cause expansion and contraction of various layers in the composite with decreased stability, and increased rust and detachment in such integral items as the Last Column and composites. This standardization of all metadata is also important for potential loan requirements. Any potential loan agreements would need to be based upon and include information about analysis and stability of the piece, specifics of movement and transportation, relative humidity control, and the environment required for its preservation. With well-developed metadata, the analysis and interpretation of the changing state of the artifacts will also modify what protective measures can be taken to increase their longevity, and the feasibility of treatment.

The use of controlled vocabulary has been particularly problematic for the WTC Archive due to the large amounts of text currently used to describe disparate objects. Table 2 illustrates the need for clearly defining core and non-core data identifiers, as well as a hierarchical schema for levels of object information. Non-standard text and metadata elements will greatly reduce the utility of this data for searches, images management and access.

Table 2. Complex Object Descriptors for the WTC Archive

Description	Material	Notes
Column	Steel	Due to axial overloading, this column bent into a "U" shape. A built-up steel section, no buckling of steel on compression side of the bend, one tear on tension side of the bend.
North Tower Antenna	Steel	This part of the antenna is the highest accessible point of the North Tower. A steel pipe ladder extended through the interior of the antenna, ending at a hatch at the top of the 3.5 ft.x3.5 ft.

		platform 325 ft. above roof.
Structural Triad	Steel	North Tower façade structure. Located at an elevation of approx. 70 ft above the concourse level. Sections of stainless steel mullions attached to the sides of the column.
Exterior Column with Spandrel	Steel	North Tower façade structure. Located at an elevation approx. between first and second floors. The following text is painted on the steel: "SAVE" and "5 NORTH" in orange spray paint.
Beam	Steel	Beam has been slightly bent. At one end, the web and one flange have been cut away. No visible identification markings on the steel.
Tower Exterior Wall Steel	Steel	One of three columns that were part of a typical tower exterior wall prefab panel. Both ends of the column have been cut for removal. No visible identification on steel.

Conclusion

The value and utility of preservation digital image archives relies on the effective creation, maintenance and management of standardized metadata elements. While deterioration is inevitable for cultural heritage objects, it can be mitigated and controlled through careful analysis and monitoring of artifact conditions and environmental parameters. The database and image assessment requirements of both the FRIL and the WTC archives demonstrate the need for precise, well-defined and carefully managed metadata to support useful analyses with a preservation archive. Preservation metadata and artifact image analysis supports a range of object requirements including:

- Control of the environment
- Storage and movement
- Exhibition and display
- Loan requirements.

With development work still underway on these two digital image archives, standardized metadata elements and vocabularies are essential to creating a workable and interoperable worldwide preservation archive, as new ground continues to be broken in this area of artifact conservation. Other conservation object identification databases exist, but there are currently limited efforts to develop and establish deterioration data archives, so critical to cultural preservation. Image analysis and a defined vocabulary are critical to standardizing deterioration and effectively assessing artifact images to aid preservation by controlling the influence of key environmental parameters.

The ease of web accessibility allows participants in international collaboration efforts to gain global access to preservation information. This ensures that artifacts of similar materials, time periods, and conditions can be studied through a comparative archive of images and associated data to allow informed preservation and conservation decisions to be made. With

these projects, the main issues have been 1) establishing an extensive controlled vocabulary to allow ease of analysis and integration of preservation images and data, and 2) accurately documenting changes in the state of the artifact and environmental information. The continued development and refinement of metadata elements for the WTC Archive will be critical to the utilization and management of this large and complex archive. While library and general museum database schema tend to be useful for cataloging, the expanded focus of preservation archives requires the integration of dynamic environmental preservation information. Establishing preservation archives to store images and textual information about deterioration rates and processes requires common information standards for the archiving, management, access and sharing of critical preservation images. With these standards we can ensure the effective stewardship of our cultural heritage for future generations.

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Fenella G. France received her Ph.D (Textile Science) from Otago University, New Zealand. After lecturing at Otago, she was textile scientist for the Star-Spangled Banner project at the NMAH, Smithsonian Institution. As an international specialist on textile aging, she focuses on links between mechanical properties and chemical changes from environmental damage, developing a comparative deterioration framework relating environmental conditions and the state of textiles. She also works on the development of textile and lighting standards.