Metadata Standardization in Cultural Heritage Imaging: A Semantic Annotation Approach

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ABSTRACT

Numerous metadata frameworks are used in the cultural heritage domain and each schema has its structure, pattern, uniqueness, and limitations. This study examines the different types of metadata schemes used for the documentation of cultural heritage images with their common characteristics and compares their appropriateness. Also, examine the possibilities and issues in effectively incorporating the metadata standards while designing the cultural heritage image systems to curtail the semantic issues and to make them interoperable with other external services. Although there are many metadata standards, CIDOC-CRM was found to be the best among others in cultural heritage imaging as it is very comprehensive and flexible with an in-depth and semantic annotation approach. However, it is found from the study that it is very difficult to develop an ontology without integrating two or more schemas, which could incorporate both tangible and intangible cultural resources without any issues of semantics and interoperability for its integration and dissemination. The study will be beneficial for the individuals, organizations, and cultural heritage institutions associated with developing digital archives of cultural heritage images to know more about the characteristics of different metadata standards and their relative advantages. The outcome of the study will enhance the current understanding of metadata standards available for the cultural heritage domain and also its selection while creating a cultural heritage image system.

Keywords: Cultural Heritage Digital Image, Image Annotation, Semantic Description, Metadata, Information Retrieval, Digitalization

Introduction

Cultural heritage is an identity, pride, and solid representation of the historical background of human society, and everyone in the society is part of it in one or the other way. Cultural heritage is evidence of human creativity, expressions, performing arts, traditional customs and rituals, belief systems, photographs, sculptures, drawings, paintings, architectural creations, historical monuments, and buildings (Kumar, 2021). It is mainly classified broadly under two categories, tangible (material) and intangible (immaterial), whereas UNESCO classified the category of sites as Cultural, Natural, and Mixed. Each cultural item holds its values and significance culturally, spiritually, architecturally, historically, or archeologically. Methods of preserving and conserving cultural inheritances are being considered as an interdisciplinary approach and has the utmost importance at local, national, and global levels. A large number of cultural resources are being converted to digitized form and many have been born digital since then the advancement of the World Wide Web started during the 1990s. The cultural heritage domain is vast; hence, its data has also become robust. Cultural knowledge is transmitted from one generation to the other through oral histories, customs, rituals, events, and traditional practices. Every cultural heritage item possesses knowledge nested in it that cannot be disclosed entirely without the benefits of words.

Cultural heritage data are heterogeneous and their data sources are often held in Galleries, Libraries, Archives, and Museums (GLAM), cultural centers, and the preservation societies. Many of them still follow traditional cataloguing and indexing methods to store and retrieve the information about those cultural inheritances. The documentation, management, preservation, and retrieval of cultural artifacts and collections involve many tasks. Developing an effective information system of cultural heritage requires the assessment of suitable metadata standards, architectural designs, ontology frameworks, classification schemes, controlled vocabularies, and language compatibility. Earlier, classifying such robust data in an information system was a

difficult task. However, enhancements in the capability of computer technologies and the emergence of semantic web technologies, ontological approaches to cultural heritage data, and the different information retrieval techniques made trouble-free preservation and dissemination of such knowledge heritage data. Today, digital networking has the immense potential to bring wide, equitable access to the texts, objects, sounds, and sights that form our global cultural heritage (Green,1998). However, effective use of metadata structures is imperative in a cultural heritage system for high audience engagement.

Though the cultural heritage collection is scattered among GLAMs, cultural heritage institutions, and preservation societies, they mainly deal with material heritages, thereby preserving physical contents. Many of them transform tangible and intangible heritage by converting physical resources into digital images, audio, videos, simulation models, and virtual realities (Ziku, 2020). On the other hand, the CHIS (Cultural Heritage Information System) including the cultural heritage aggregators handling the knowledge heritage where ICT (Information and Communication Technology) and digital technologies are being incorporated for its better management and retrieval. The latter is more focused on the standardization of its contents. Images of cultural heritage are available in different forms such as digital, photogrammetric, laser scanned, digitized, or created using various tools such as CAD (Computer Aided Design), virtual restoration, etc. Also, they differ in their file format, size, height, width, resolution, etc. Cultural heritage images are heterogeneous having a rich source of content in that requires deep semantic annotation.

Objectives of the Study

The specific objective of this study is to provide an overview of various metadata schemes used in cultural heritage systems. The study will also examine the possibilities and issues in incorporating metadata standards in cultural heritage images to make them interoperable with other external systems of similar kinds.

Related Studies

Various countries have taken initiatives aiming to highlight digital collections of their heritage by developing a cultural heritage information system. Much such research is also being conducted to make the heritage resources easily searchable and visible to the public. Publications discuss methods and tools used in cultural heritage databases and their maturity. Metadata is part of cataloguing process and helps in expanding the cataloguing data to ensure better retrieval. In a catalogue there are many essential fields to describe the item in a descriptive form or contextual form. Cataloguing requires knowledge and skills. There has been a substantial effort in the domain of cultural heritage metadata and semantic annotations. It is clear from different studies that have been performed to analyze the various aspects of cultural heritage images, metadata has its importance in the cultural heritage domain. Structured metadata standards are indispensable for describing, indexing, navigating, connecting, and sharing cultural heritage materials more widely. It enhances the visibility of the resources and provides contextual access to cultural heritage information.

A study conducted by Thekkum Kara states that along with the classification schemes and ontologies, universally accepted metadata standards and vocabularies are also to be considered while organizing the heritage items, which are being supported by the selected archiving tool (Thekkum Kara,2021). Many efforts have been seen to develop their standards, frameworks, and terminologies to represent the cultural heritage while documenting. The organizational role of metadata for information retrieval and access to cultural resources has also been identified by Maltesh *et al.* (2007). The quality and acceptance of the metadata standards are decided by their ease of use, support of local and global management of digital resources, interoperability, and semantic richness. The study of Poluru claims that there is significant scope in building a National Repository for Indian Cultural and Heritage materials with OAI-PMH (Open Archives Initiatives-Protocol for Metadata Harvesting) to ensure its interoperability with support of Dublin Core Metadata elements and DSpace digital library software (Poluru, 2009).

Various tools and semantic web technologies are used for representing and processing cultural heritage images such as automated semantic enrichment, linked open data thesauri, multifaceted ontology, taxonomies, etc. These new technologies make the access and analysis of digital forms of cultural heritage images meaningful. Further incorporation of such technologies can explicitly represent the image content systematically and

semantically. The rich source of information packed in each cultural heritage image is represented beyond the basic metadata facet level.

The only possible way GLAM is followed is to provide a detailed description of the images in the description column which may not be the part of retrieval process. Appropriate tools, techniques, and methodologies have to be adopted to enhance access and retrieval. Each image in a collection needs to be semantically enriched and interlinked. The system used in organizing the collection should also enable interoperability which is essential to improve information sharing among the communities.

Metadata for Cultural Heritage Images

As commonly known, the general definition of metadata is 'data about data' which is also called 'information about information'. It is descriptive information about collections and plays a significant role in organizing, describing, searching, and enhancing access to the resources available in a collection. Rather than categorization, metadata increases discoverability. In a networked environment metadata plays an important role in identifying, accessing, collecting, storing, retrieving, and preserving the resources. It is all about answering about an item on what, when, where, creator, and security restrictions. Hence it eases an item to be identified, understood, and found easily. Metadata is significant in providing the detailed image data structure of a cultural heritage item and it denotes the quality or characteristics of data and is vital for publishing, accessing, and adding value to resources.

The richer and interlinked metadata improves access to cultural heritage information and helps to make it easily searchable and discoverable. Hence the choice of metadata standards for cultural heritage image organization is important. The selection of metadata standards is part of digitization and its documentation process. Metadata has a significant role in resource search and discovery across an information system. Schemas are built from individual components, i.e. metadata elements and are designed to describe particular information. Metadata schemas can be viewed as standards describing the categories of information to be recorded. They ensure consistency in metadata applications and support interoperability of applications and resource sharing and depending on the element definition each element contains a particular category of information, however, not all schemas contain the same elements, as the needs of users differ Peneva *et.al. (*2009). Adopting such schemas promotes data sharing and improves data management. A metadata schema allows to inclusion of as many data fields or elements as possible about a particular item.

Advancements in computer and communication technologies provide opportunities as well as challenges for the cultural heritage community in the networked environment. Unlike other information systems, cultural heritage information systems should provide abundant semantic information about the item's creation, and content to access and retrieve the item precisely. Although the field of information retrieval is closely associated with computer science, it originally emerged from library science — also one of the main disciplines concerned with access to cultural heritage material Koolen *et.al.* (2009). The volume of metadata used for cultural heritage images is increasing due to its heterogeneous nature. Cultural heritage data for both tangible and intangible items require the support of robust metadata standards.

Semantic Approach to Cultural Heritage Image

As cultural heritages are being digitally archived day by day there needs to be use of appropriate metadata standards so that locating, managing, and retrieving of data becomes easy. The advent of concepts like virtual reality, augmented reality, mixed reality, metaverse, etc. has led to a revolution in archiving especially in the field of Cultural heritage. These technologies not only create images in 3D but also provide an actual and permanent photographic record which results in rivalry among museums and CHI to create 3D images for display as well as preservation. It is also inevitable for professionals and archivists to move from 2D to 3D over its benefits. Technology like photogrammetry, SfM, LiDAR, Light Scanning, etc., are used in creating 3D images.

Most of the metadata standards available are efficient in describing the visual features of cultural heritage to retrieve its contents. However, it is difficult to find a single comprehensive metadata standard that can extensively describe all the properties of the cultural heritage domain. Cultural heritage resources are

heterogeneous and embedded with complex knowledge. Considering the heterogeneous characteristics and the comprehensibility of cultural heritage images in the digital form, it is not sufficient to represent the internal features of the contents in detail with the existing metadata standards. Unlike other digital contents, digital images of cultural heritage contain robust and complex contextual information hence it is essential to annotate the characters and objects depicted in the image. In a cultural heritage image, an individual object or work may be composed of multiple parts or components. Many images or objects or works can appear for the same item and a single image can also depict multiple works. In both cases, when more than one work emerges in the same image or more than one image appears for the same item different data structures have to be recorded. Some are created in series, components, sets, or volumes. Further records of related works having conceptual relationships are to be linked to each other to enhance their search and retrieval capabilities. In a cataloguing process, it mainly focuses on the description part of the work. Image content semantics are to be identified, recorded, and revealed. Individual characteristics or attributes of a particular cultural heritage image need to be described effectively to get in-depth information about each segment. Entities inside the cultural heritage image need to be represented precisely and context-specific to display its internal features. Semantic information is embodied in each cultural heritage image.

Access to cultural heritage information systems has improved with the advancement of new digital information technologies. There are many metadata standards developed globally to curtail the semantic issues associated with cultural materials and to integrate digital cultural heritage information on a large scale. These data structures facilitate semantic interoperability of heterogeneous cultural heritage information in the global information environment. Standard data structures not only provide interoperability but also facilitate good practice of conceptual modeling for advanced searching and browsing features. The data interchange is possible only when the single scheme is used by different agencies. A typical metadata scheme possesses essential elements such as owner, possessor, name of the cultural heritage, characteristics, location, age, category, whether protected or non-protected, identification number, present status, and condition. Out of many models available for data organization some of them are directly connected with the cultural heritage objects. A few of the major metadata standards that are widely used for the global information integration of cultural heritage resources are briefed here with their comparative advantages in the context of cultural heritage image systems.

Dublin Core Metadata Standard

The extensible architecture of Dublin Core helps communities build their own sets of qualifiers and additional elements which makes it possibly very flexible for users to operate and handle with the help of again a very influential DCMI tool application profile. The new DC Libraries Application Profile supports the use of role values as semantic refinements for Creator, Contributor, and possibly Publisher (Guenther, 2002). Dublin core uses XML with its extensibility for digital description of items which is supported by nearly all software and hardware for data storage and data transfer which makes it very much interoperable but does not support SGML whereas SGML makes it possible to add markup (extra, non-intrusive information) to existing documentation, database records, full-texts, catalogs, and images, making them available directly for electronic access.

CIDOC-CRM

CIDOC –CRM is a metadata standard for cultural heritage institutions developed by CIDOC, working under the International Council of Museums (ICOM). It integrates information from different heterogeneous sources related to cultural heritage and presents it in a meaningful, structured, and formal way which is very easy to comprehend. It is based on the entity-relationship model. Entity is shown by Class and the relationship between two classes by Properties. There are 86 classes and 137 properties whereas previously it was only 56 core classes with an object-oriented approach which made it complex to use. These classes are related to one another in single or multiple inheritance giving rise to class hierarchy.

The best part of CIDOC-CRM is that unlike Dublin core it has used “one to many”, “many to one” and “many to many” relationship principles which give a semantic idea of the domain and maintain its monotonicity. It also makes searching easy by accumulating different entities with similar properties together. CIDOC CRM uses formats like XML, SGML, and XrMLunlik DC which does not use SGML or XML. For the technical

description especially for the scientific community, CIDOC provides an extension known as CRMdig. CRMdig provides the classes to model a measurement device, a measurement, a person conducting the measurement, the digitization process, and annotations added to the digital scan Homburg *et al*. (2021). It helps in mapping different aspects of the cultural artifacts like people involved in digitization, equipment used, its measurement, time frame, and many more which is very much crucial for the recent era to describe as these are the only things that scholar community would desire to know in future other than the general description. CIDOC –CRM game is also available to learn the CRM ontologies and these ontologies are held by a defined language of CRM called TELOS.

FRBRoo

It is an extension of the FRBR model and is based on object-oriented methodology. It is a formal ontology that captures and represents the underlying semantics of bibliographic information and therefore facilitates the integration, mediation, and interchange of bibliographic and museum information. It is the result of the FRBR/CIDOC CRM working group formed in 2003 and presented its first version of FRBRoo in 2010 (CIDOC CRM, 2010) . FRBRoo inherits both the event-centered analysis of CIDOC CRM and the "WEMI" (Work, Expression, Manifestation, Item) structure of FRBRER Bekiari *et al.* (2012). It is purposely designed to achieve interoperability. However, it follows the same categorization that was in the Group 1 entity of FRBR namely work, expression, manifestation, and item. As it contains all the concepts of CIDOC CRM it has extended the FRBR family to cultural heritage materials. The harmonization of the two institutions namely FRBR and CIDOC CRM led to fixing many problems which was in the FRBR model previously. For example, the issue of time was not properly addressed in the FRBR model and many concepts like 'temporal entities", "events" etc. were properly introduced. However, some classes of FRBR were made subclasses for clearing concepts.

METS

METS stands for Metadata Encoding and Transmission Standard. It is an open standard with a modular structure. The Library of Congress is maintaining agency of the METS standard. It contains 7 sections such as METS header (<metsHdr>), structural map(<structMap>), descriptive metadata(<dmdsec>), file section (<filesec>),structural links (<smlink>), behavior section (<behavior>) and administrative metadata (<amdsec>). It uses XML schema format for the exchange and managements of metadata between different repositories which makes it highly interoperable. METS meets the flexibility criteria as it is extensible meaning that a description of an item can be extended beyond the current schema that may be available to describe objects (O'Neill and Stapleton, 2022). This has helped the standard in describing different cultural artifacts with multiple instances of descriptions. METS can be used for both tangible and intangible cultural heritage resources. Since many oral histories are now being digitized from analog tape recordings or born-digital through digital recordings, METS can be a useful schema for using metadata with these digital audio files(Cheslow, n.d.). One needs to create a METS profile in order to create the METS description as it describes the legal entities in the METS description (LOC 2021c). Different institution makes different profiles as per their need and also on institutions can share their METS profile with others for the same object if needed which gives the standard a high advantage concerning other standards.

MODS

MODS is another metadata standard that is recursive and it can include multiple hierarchies inside a single mode record Sameer Gul *et.al.* (2015). The comparative statement of Stapleton et al. found METS structure is far richer than others Stapleton *et al. (*2019). A comparative study of a different metadata schema for cultural heritages performed by Sameer Gul and et.al. explains the benefits of MODS over Dublin Core where he suggested that Dublin Core has 15 top elements and 28 sub-elements whereas MODS has 20 top elements and 47 sub-elements. As a result, MODS provide richer description.

Major findings of the study

The metadata standards are to be broadly categorized into two categories based on their foundational approach i.e. Object-Oriented Approach and Event Centric Approach. Here, CIDOC-CRM and FRBRoo both follow event event-centric approach while DCMI and METS follow an object-oriented approach. Cultural heritage images are mainly focused on event event-centric approach as it is far richer in maintaining semantics among

the metadata and provides an ontology that gives an overall view of the particular domain. That has become the reason for making CIDOC CRM, the international standard (ISO 21127:2006) for the controlled exchange of cultural heritage information between various memory institutions like archives, libraries, museums, and others Lourdi*et al*.(n.d). However, due to complex terms and their ambiguous definitions for entities makes their use complex for the end users. For this, Lourdi *et al.* suggested combining CIDOC/CRM and Dublin Core Collections Application Profile to resolve difficulties in search and query by the end users as Application profiles are something that provides a clear legal definition of terms used in the schema. A problem with Dublin core is that it uses the "one to one principle" (DCMI 1:1) which means distinct entities should be described by conceptually distinct descriptions as per DCMI definition but cultural heritage images nowadays follow "one to many", "many to one" and "many to many" principles in which they combine two or more distinct entities having distinct description but similar properties.

Cultural heritage images contain rich information in it have to be explicitly represented with deep semantic annotations to provide better search and retrieval. Further, related resources within the domain have to be interlinked to access them effectively and precisely. However, it is a challenging task to evaluate the richness of the metadata of the content of a cultural heritage image qualitatively. Contextual accuracy of the metadata with the implicit and explicit contents of the cultural heritage image also is a challenging task. All the above standards namely Dublin Core, CDOC-CRM, FRBRoo, and METS are very rich in assigning metadata for cultural heritage documents and also for the integration of these metadata for interoperability and are also flexible and comprehensive to use but only CRMdig of CDOC CRM is currently capable of assigning metadata for different facets of digitized resources besides the conventional ones. none of them have worked in the integration of metadata related to technologies associated in digitization of these heritages. They have not created any metadata standards that can define such things.

It has been found from the analysis that the advances that have been made in metadata standardization in the cultural heritage contest are truly encouraging. A considerable number of metadata standards are being utilized for representing, organizing, and disseminating cultural heritage data. GLAM and other memory organizations contribute at higher levels to the development of metadata to provide contextual information about the contents in it and to make the resources interoperable in the networked environment. Metadata and metadata schemas are very essential to improve the sharing of cultural heritage resources to a wider population. Semantic gap between the metadata schemas are always a challenging issue to ensure the metadata interoperability. The comprehensiveness and granularity of cultural heritage images including its hierarchical descriptions provide a better scope for its usage. Existing metadata schemas are effective in describing the shallow attributes of cultural heritage digital images. However, image content description is very essential in cultural heritage digital images which require a comprehensive metadata schema. Un-annotated images miss the visual as well as semantic features. Context-specific, semantic analysis and indexing is very much required for an effective retrieval of cultural heritage images. Expert assistance is required to identify the contents and to avoid missing any major semantic descriptive information associated with the cultural heritage image. Domain-specific terminologies with proper ontological frameworks to be followed to accommodate the maximum contents, to satisfy the user's approach from different angles.

A study of Hirwade comparing metadata standards suggested that a single standard fails to fulfill the entire metadata requirements, hence a combination of two or more standards is made to get better results (Hirwade, 2011). The metadata should be as user-friendly as Dublin core for use and understanding and it should also be flexible like METS so that it can easily go beyond the current schema for describing objects. Metadata related to technical assistance used in the digitization of artifacts in 2D or 3D should be given space in the schema as it urges the scientific community to incorporate those and CRMdig is a well-set example for the same. It should also apply an event-centric approach like CIDOC CRM as it is very helpful in general but should not be made complex. The legality of terms in the schema should be well defined so as not to create ambiguity and it should be analytico-synthetic in an approach that the local end users can create their elements if found necessary. It should also be easy to move around different metadata schema if found necessary. A well-defined ontology of elements or entities should be available to cover the whole CHI domain either in tangible or intangible form.

Conclusion

Metadata helps access to cultural heritage resources in a networked environment. Interoperability of metadata as well as sharing information about the metadata schemas is very crucial in improving the information sharing process in the networked scenario. Developing standard metadata schemes helps to improve content management and make documentation uniform thereby facilitating data interoperability. Considering the complexity of cultural heritage objects, a constant extension of common metadata standards is very essential. There are many metadata schemas developed specifically for creating metadata for cultural heritage resources. There is a variety of new cultural domains in both tangible and intangible forms for which improved metadata schemas are to be designed. More importantly, it should be capable of dealing with any metadata structure at subject, collection, and item levels. Data models are playing a pivotal role in designing the metadata schemas. There is a pressing need to understand the significance of standardization in the use of metadata in cultural heritage documentation. Cultural heritage data are heterogeneous hence not always desirable to use a single system as they always have a potential gap. Unlike digital images, a cultural heritage image contains valuable information embedded in it in the form of symbolism or narrative. The efficiency of search retrieval of cultural heritage information systems can be affected if the gap between the terminology used by users and the metadata used is greater. Hence, it is significant to explicit the contextual information about the contents it possesses, using an appropriate metadata schema, so that it can be enriched, exploited, and utilized at its optimal. However, creating a single and comprehensive metadata schema to satisfy all the requirements of all the communities is not realistic in the cultural heritage domain.

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