Archiving and Management of Digital Images Based on an Embedded Metadata Framework

Liu, Cjien-cheng
National Taiwan Normal University, Taiwan
695150038@ntnu.edu.tw

Chen, Chao-chen
National Taiwan Normal University, Taiwan
cc4073@ntnu.edu.tw

Abstract

Digital image files and metadata are critical functionally-related components of digital archiving and management. However, as digital image files and their metadata are usually independent, applications dealing with them have proven to be relatively complicated. This research attempts to develop metadata storage and exchange through extended techniques of embedded metadata, in order to combine information about files with the files themselves and further extend and control other related information. An Embedded Metadata Framework (EMF) structure will be planned as a reference platform for development of embedded metadata in the digital archive system. Finally, remaining problems to be overcome in such applications will be identified for future research.

Keywords: embedded metadata; technical metadata; file properties; digital preservation; Adobe XMP.

1. Introduction

Metadata is regarded as important in applications for Digital Archives. It can record and describe digital objects, and is commonly used for description, identification, recording, direction, copyright statements and file access control.

The information related to digital image files includes file format features data (such as height, width, color modes, resolutions, created dates, etc.) and descriptions of the content of image files that including dates-taken, locations, photographers, people, events, topics and subjects. All descriptive information is important at a certain level though not all of the information mentioned above will be recorded or saved in a digital file. (DIG35, 2000)

Normally, photographic equipment cannot capture and record the location, objects or events in the photos. Therefore, it cannot record this information in digital image files. (DIG35, 2000) For improvement, quite a few digital library and digital preservation developers make another set of metadata which aims to rebuild connections between the descriptive information and digital image files. For example, some researchers use a metadata XML file to show the contents of the digital files or connect metadata to the digital image files through Web-based database and Semantic Web systems. These application services not only link metadata and digital image files but also enable demonstration and search of descriptive digital image files.

Maybe it is good to build mutually-corresponding connections between metadata and digital image files by using an information assistant system but these files may exist independently. Under the circumstances, we can not understand the contents and other related descriptions of the photos immediately after they are downloaded. The only way to identify the photos is to either check up the file names or track back the save routes during downloading. In other words, without other assistance from the information system, it is impossible to identify photos and retrieve additional information other than by opening each photo one after another.

Most of the time, we cannot pick the subtle difference between two similar digital image files, but professionals or interested parties perhaps can. That is why embedded metadata, one of the application techniques for combining metadata and digital image files, is important.

In this research, the aim is to provide a method that allows the related descriptive information, tangible or intangible, to be saved and accessed any time by people or the information system.

This research probes a variety of metadata application techniques, methods and criteria; further, analysis and testing will be done later based on the specifications and characteristics of each digital archive in order to find the best structure of metadata for digital preservations. Finally, we propose the Embedded Metadata Framework (EMF) for future research in digital preservation as a reference standard and basic development module.

2. Overview: Information of File

The structure of each digital file, from basic information characteristics to descriptive content, contains three types of must-show information: file properties, file information and embedded metadata.

2.1. File Properties

During digitization, the basic common information, including file names, file format, file sizes, and created dates, will be constructed and shared among electronic equipment and information appliances for management and retrieval. In other operating systems, such as UNIX, owners/creators or file access permissions may be shown as well. The information mentioned above is so-called file properties and must be contained in each file.

2.2. File Information

With advances in technology, more and more types and formats of digital media are produced; and due to the use of different programs, more different corresponding formats are generated. In this case, each file contains a unique package of file information.

File information varies with formats and media types, shown as follows:

TABLE 1: Media Type and File Info

Media Type	File Info	Example	File Format
Images	Resolution (Width, Height), Color Mode, Color Deep, Compress rating, Count of Pages.	800x600, RGB, 8bit, JPEG	TIFF, JPEG, BMP, GIF, PNG...
Documents	Layout size, Pages, Include fonts	A4(210x297mm), 10Pages	Word DOC, PDF...
Multimedia: Film	Dimension (Width, Height), Film length, Frames per Second, Sampling rating, Compress rating, Encode/Decode	720x480, 00:01:25, 30fps, 256kbps, MPEG 2	WMV, MPEG, AVI...
Multimedia: Audio	Audio length, Sampling rating, Compress rating, Encode/Decode	00:03:38, 44.1khz, Stereo, MP3	WMA, MP3, WAV...

The four common formats and types of media are present widely in digital preservation.

2.3. Embedded Metadata

Other descriptive digital information is not produced automatically but manually after a file is generated, including descriptions of the contents, events or created types. These annotations may contain titles, creators, abstracts, descriptions, captions, categories, keywords and even copyright statements.

These bunches of information can be added to the file and retrieved through the same applications or programs at any time. For example, we can use Microsoft Office to open a Word.DOC file and edit its abstract. Also, we can use Adobe PhotoShop to edit TIFF image files. These designs and concepts are exactly what the research intends to discover and develop.

Embedded Metadata Technology adds the descriptive information into additional space in the digital file and assigns the one section address of Flag, Block or Tag to store it. Most additional metadata is binary encoded and stored in the Header section. Therefore, the space is limited and difficult to interpret back into plain text. Instead, metadata can be transferred into the digital archives in XML format which can be added in the extension section of the file and saved in the designated location.

Unfortunately, the additional bunches of information must be processed in structured digital image files so, only some specific formats, such as TIFF, JPEG or PNG, are able to absorb metadata in image files (Adobe, 1992, 2005).

3. Standards

The literature review and analysis of embedded metadata, along with the descriptive specifications of metadata recorded in image files, help form the following important related operating standards, regulations and designs, inclusive of DIG35, technical metadata, MIX, Z39.87, IDEAlliance (DISC, PRISM), METS, JEITA EXIF, CDWA, VRA, DCMI, DICOM, IPTC Core and Adobe XMP. We now introduce these.

3.1. DIG35

Digital Imaging Group (DIG) is a non-profit visual arts education and social organization comprised of Adobe Systems, Canon, Eastman, Kodak, Fuji, Hewlett-Packard, IBM, Intel, Live Picture and Microsoft. They established the DIG35 Initiative Digital Image Promotion in April, 1999. They are the first team to apply embedded description information to management of digital photos. (DIG35, 2000)

DIG aimed to promote and provide a standardized mechanism. It allows users to access, retrieve and exchange image files freely. The characters of XML are cross-platform and in a unique language that is ideal for describing conceptual information. Thus, DIG brought forward Metadata Standard for Digital Images in 2000 and confirmed the regulations of the DIG35 Specification v. .0 which adopted W3C's XML/RDF as its unique format.

The promotion team was dismissed but the milestone was set. ANSI/NISO Z39.87 Technical Metadata, DISC and IPTC referred back to their idea to design appliance standardizations for image metadata. Currently, documents and records of DIG35 are restricted to I3A only for custody.

DIG35 attached metadata to the end of an image file so as to contain basic image parameters and intellectual property rights. The structure is shown below:

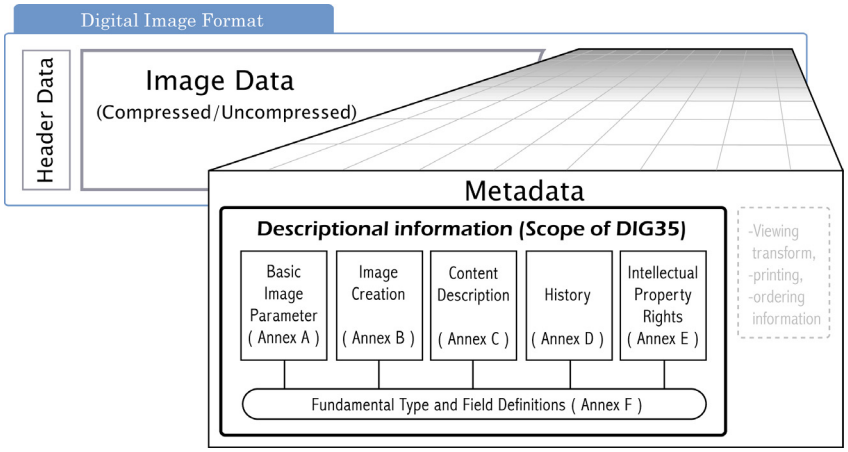

FIG. 1. DIG35 Digital Image Format. (DIG35, 2000)

3.2. Technical Metadata and Z39.87

Technical Metadata was developed by The Library of Congress "Network Development and MARC Standards Office" It is used to allow electronic equipment to recognize related information in digital archives—Metadata for Images in XML Standard (MIX). The standard was expanded into Technical Metadata for Digital Still Images Standards for ANSI/NISO Z39.87-2006 in 2006. MARC, which was originally used in libraries, is now applied to digital images and descriptive annotations of electronic files. (Library of Congress, 2008; ANSI/NISO, 2006)

3.3. IDEAlliance

Digital Image Submission Criteria (DISC), is an association to promote digital image application under IDEAlliance. It owns a large number of techniques and operating standards for management and application of image files, including DISC, PRISM, AdsML and PROSE/XML. They aim to promote the printing industry and develop applications of the publishing techniques. (IDEAlliance, 2009)

The important parts of metadata in DISC are contact information, instructions and job ID, the photo owners of the copyright, as well as the reproduction history of photos. Further, the operating actions are recorded for art technicians and printing professionals to follow.

3.4. IPTC

The International Press Telecommunications Council (IPTC) takes charge of the descriptions and establishment of photos in the fields of news and communications; they also set up the standards for NewsML descriptions. IPTC Standards Committee, under IPTC, proposed the IPTC Information Interchange Model (IIM) in 1991 as shared regulations to enable the exchange of information descriptions in the news and communication industry. (IPTC, 2008)

What counts for recording in metadata is photographers, contact info of copyright owners, take-locations and backgrounds when applied to news reports. In terms of IPTC core structure, the important information elements are contact info, scenes, subjects, copyright notices and instructions.

3.5. Adobe XMP

eXtensible Metadata Platform (XMP), developed by Adobe Systems Corporation, is designed for exchange of embedded metadata of digital files and descriptive information. It was first in Acrobat PDF 5.0 in Portable Document Format (PDF) to add annotations which make electronic documents identifiable and searchable. Cooperating with IPTC, Adobe released IPTC IIM for the information exchange platform 'IPTC Core Schema for XMP' among news media. The future for image files with descriptive information embedded thus unfolds.

XML structure for the whole XMP encompasses header, serialized XMP, padding and trailer to deal with abstracts, XMP metadata documents, expansion and extension respectively. The main XML contents of XMP are shown below:

```
<?xpacket begin="■" id="W5M0MpCehiHzreSzNTczkc9d"?>
... the serialized XMP as described above: ...
<x:xmpmeta xmlns:x="adobe:ns:meta/">
<rdf:RDF xmlns:rdf= ...>
...
</rdf:RDF>
</x:xmpmeta>
... XML whitespace as padding ...
<?xpacket end="w"?>
```

FIG. 2. Adobe XMP XML sample.

XML documents begin with <?xpacket begin="■" id="W5M0MpCehiHzreSzNTczkc9d"?> and end up with <?xpacket end="w"?>; "■" signifies Unicode's 'zero width non-breaking space character' (U+FEFF), in the wake of id="W5M0MpCehiHzreSzNTczkc9d" as a unique identification.

The special design, begin="■", and texts, id="W5M0MpCehiHzreSzNTczkc9d", attempts to allow access programs to search for the existence of XML documents. The tag, <?xpacket >, in the 'end' marks the ending while w or r refers to the capability of the documents for the purpose of writing or reading. (Adobe, 2005)

4. System Design

The system design in this research adopts the format developed by the Web-based information system to run the embedded metadata through Adobe XMP technology applying to Digital Preservation Systems. This system design includes Embedded Metadata Framework (EMF) definitions, digital preservation system architecture and end-user operating design, illustrated below respectively:

4.1. Embedded Metadata Framework (EMF)

EMF architecture is created as a shared reference model for embedded standards of metadata in digital images; it is also intended to provide a frame for exchange of information among platforms. To achieve this, a dominant standard is needed as a core of EMF to access metadata by the systems, inclusive of tools, applications, database, and search engines.

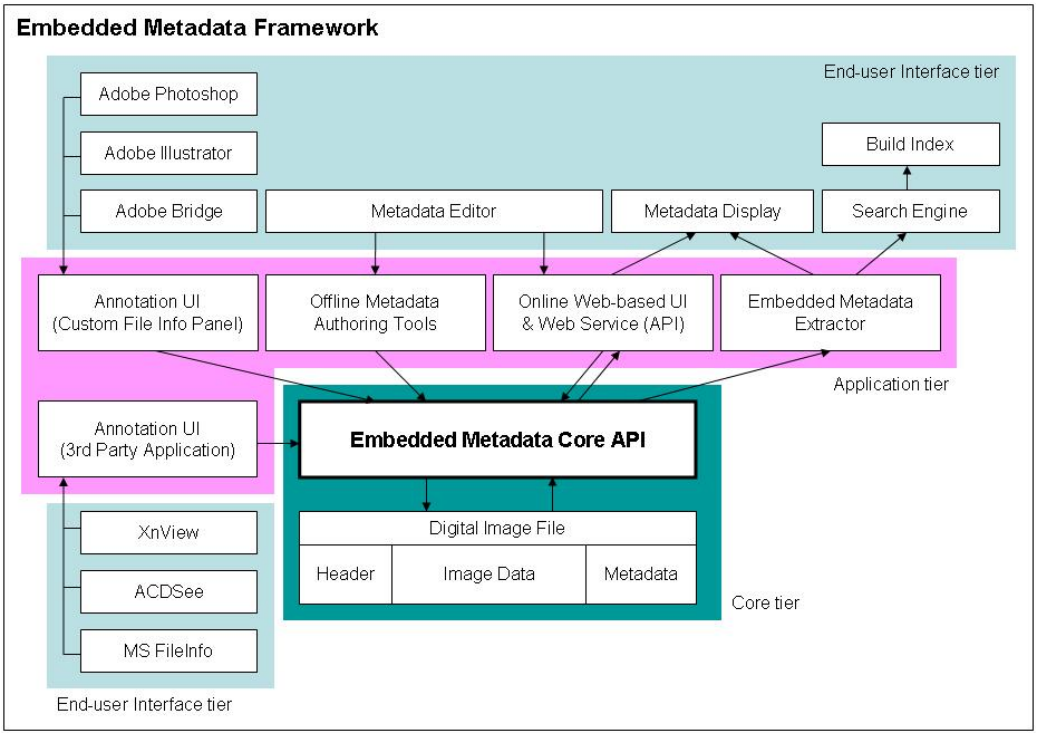

FIG. 3. Embedded Metadata Framework.

EMF architecture follows an n-tier core, application and end-user interface. The data structure is based on XML/RDF and adopts Unicode (UTF-8) as data storage codes while EMF cores are packed by Adobe XMP API to communicate with other programming languages and develop further.

Among an array of application techniques and standards for embedded image descriptions, the research selects Adobe XMP as the core structure of EMF as a result of:

- Specific definition, standards and data synchronized design

  Adobe XMP defines regulations and application profiles of metadata clearly. It follows the structure of namespaces which combine columns with the same attributes of metadata with different structures. At the same time, the updates will be processed. For elements with the same concepts, this saves users from having to input information among different metadata time and again. For example, someone might name himself or herself Creator in Dublin Core, By-line in IPTC, and Author in other applications.

  Apart from the clear definition from Namespaces, the standards of access to XMP info in image files are clearly stated; all specifications for each individual image file are definite. Please also refer to Adobe XMP Specification documents. (Adobe, 2005; 2008)

- Unicode and XMP/RDF Standards

  Adobe XMP conforms to Unicode and supports UTF-8 and UTF-16. It accommodates data editing in multiple languages; quite a few data produced during the Japanese colonial period in Taiwan need to be interpreted in Japanese and Chinese.

  XMP adopts XML/RDF format by W3C to record data that allows data to be accessed, edited and exchanged more easily. (Adobe, 2005)

- Customize and Expansive Metadata

  Adobe XMP allows users to customize and expand metadata formats on their own demand, including descriptions of content without limited regulation and columns. Users only have to follow Adobe Corp released XMP metadata namespaces and rules. It helps development of the Digital Preservation Systems. (Adobe, 2008)

- User-friendly operating Panel

  Adobe XMP provides a 'Custom File Info Panel' which allows users to process metadata editing in image files on demand. (Adobe, 2008)

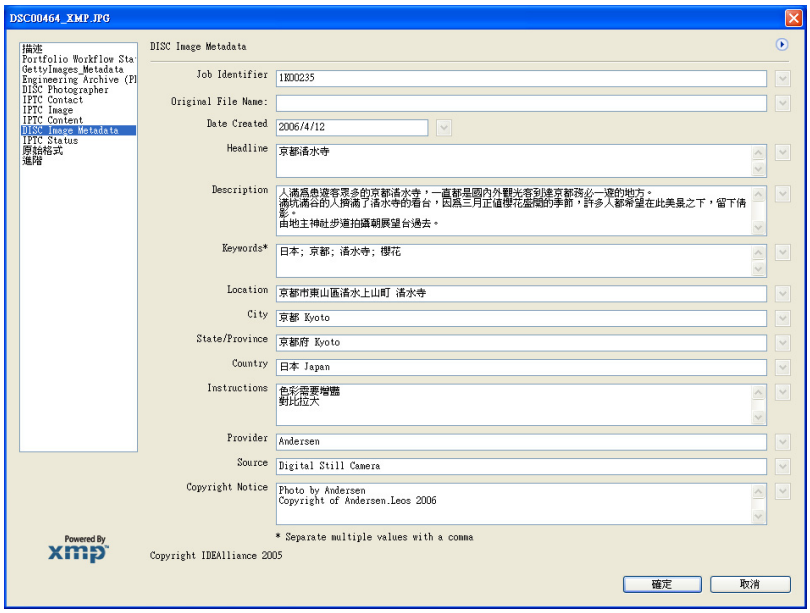

FIG. 4. Adobe XMP Custom File Info Panel.

- Open SDK and Toolkit

Adobe offers free and open developing kits and other related documents which allow technicians and operators to develop and design XMP applications which can support more programming languages. In doing so, it is easier to do promotion and application of the systems. (Adobe, 2005; 2008)

4.2. System Architecture

Adobe XMP, the core technology of EMF, is implemented to form the application system for digital preservation. The system includes annotation works, editing metadata, EMF process, transmitting image files to a database, and display for the data.

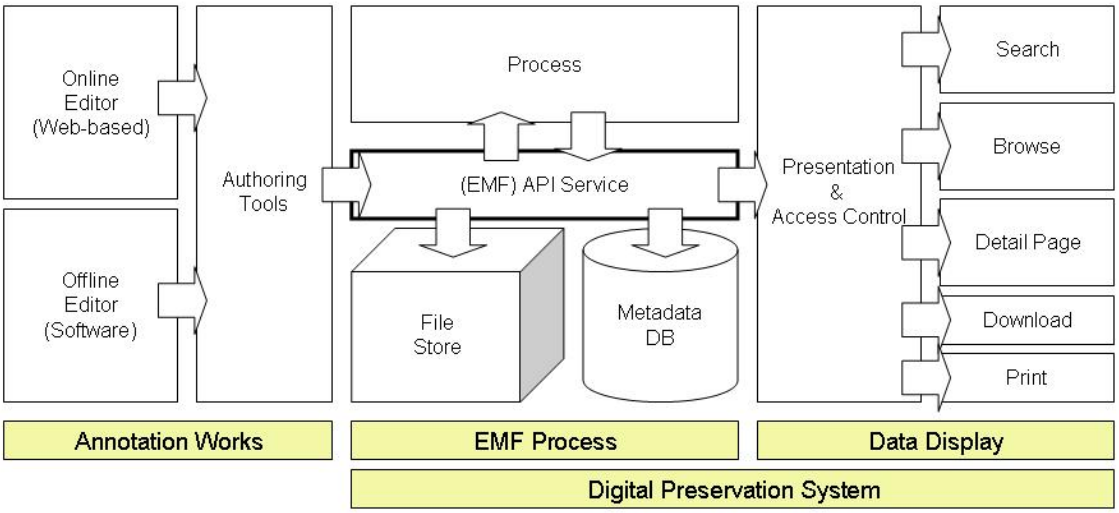

FIG. 5. System Architecture.

- Annotation Works

  Metadata editing can be completed offline or online, written into image files and saved in the Web-based system. It can be developed in independent editing platforms to enable the process to be distributed. Therefore, editing tools can be customized and incorporated in accordance with the needs of the editing teams.

- EMF Process

  The core includes the operating process, API Services, a database to save metadata and disks to save files (Digital Object). Of them, API Service runs uploading, linking and access database, transmission of image files, production of resized images and rebuilds the index for the search engine. The process includes database input, embedded metadata access and builds the metadata in the database.

- Data Display

  Data Display aims to display and control data. The system provides browsing and searching of records for digital preservation. Through the detailed browsing, data are allowed to be downloaded and printed. Further, illustrations can be personalized in accordance with characteristics so as to demonstrate this uniqueness.

The three operating processes compose a digital preservation system and online editing works system. The design allows the access of XMP when data is saved in the database and avoids building up files separately. The system can download, browse files and retrieve image information, including the related metadata, even in the offline state.

4.3. Working flow

The process of embedded metadata and working flows of digital preservations applications are shown below:

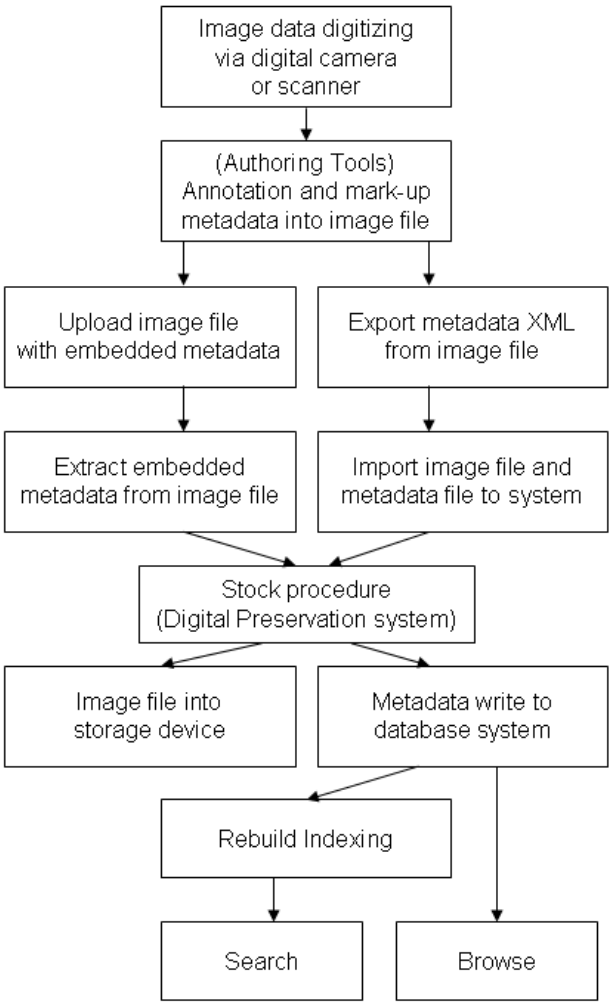

FIG. 6. Operating and Working Flow.

- The system will add the related digital information in the digital archives in the process of digitalization, such as EXIF.
- Metadata descriptions are established by editing and saving in the digital image files.
- If the digital preservation supports the EMF platform, it is possible to access embedded metadata during uploading to the system. The traditional digital preservations adopted standard XML exchange; meanwhile, embedded metadata can be extracted and transformed into XML and saved in the digital preservations.
- When metadata is saved, the digital archives will be preserved in storage for indexing by search engines.
- Browsing is allowed through the indexes in the system; browse and retrieval are possible through the records in the database.

4.4. System Preview

The concepts and planning mentioned above can be practiced by prototype as shown below:

FIG. 7. EMF Metadata display.

This interface contains file properties and metadata of the digital image files. The file properties on the left-hand side are automatically produced when the file is generated by digitalized information facilities. They cannot be revised. Metadata on the right-hand side is established manually which allows amendment. It also supports input of text and demonstration in multi-language.

Adobe XMP is served as EMF core by the system. The definition of the metadata structure can be customized. The sample used here is the metadata schema of IPTC core.

Most of the digitalization facilities for images, such as digital camera or scanners, enable the related records to be saved along with the files during the digitalization process, for example: models, serial numbers, and other related photo information. Some of the digital photograph facilities are able to provide files with GPS (Global Positioning System) records through the photos taken along the way, by GeoTag. When these records are transmitted into digital preservations, they can be combined with GIS (Geographical Information System) or Google Maps so as to mark up the take-locations.

The photograph information mentioned above can be linked by [Show EXIF] which makes retrieval of the information possible, as shown below:

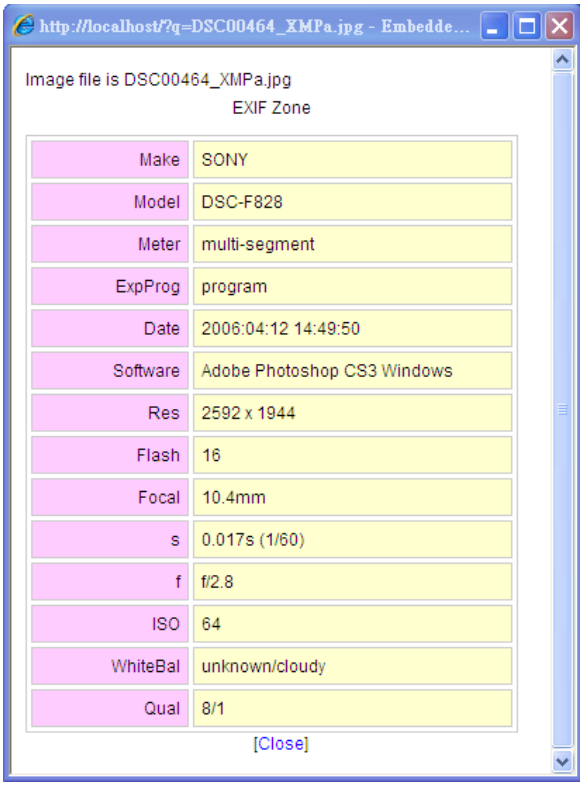

FIG. 8. Digital Still Photographic EXIF information.

The editing of embedded metadata can be completed offline with packages of software such as Adobe PhotoShop, Adobe Bridge or the self-made Web-based Metadata Editor, shown below:

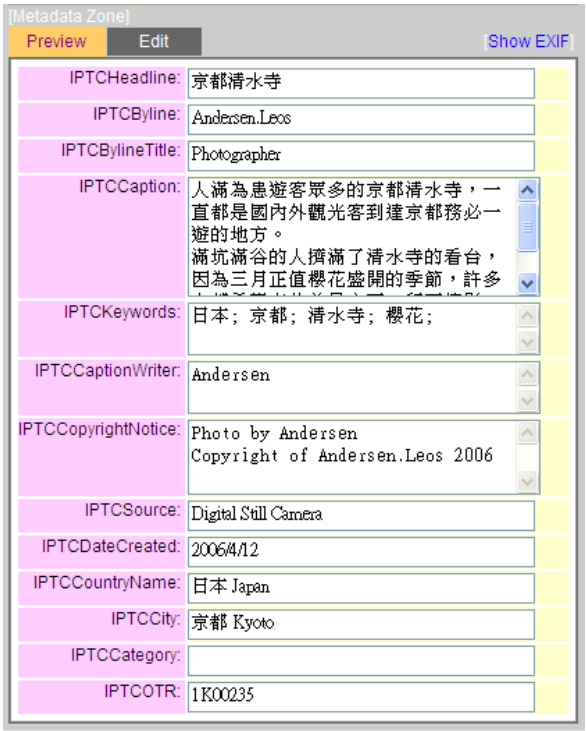

FIG. 9. Web-based Metadata edit interface.

When a file is downloaded, the metadata will still be contained in the digital image files. Abstracts can be retrieved through terminal user operation, or other software with embedded metadata, as shown below:

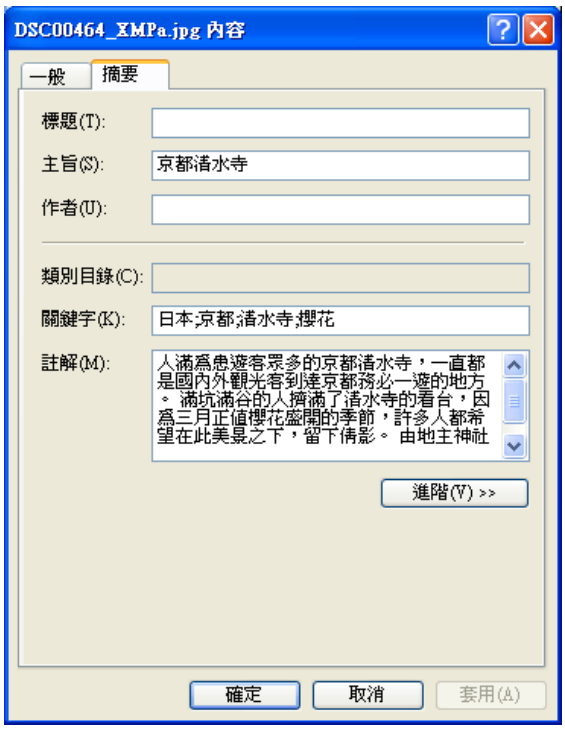

FIG. 10. Windows – File abstract preview.

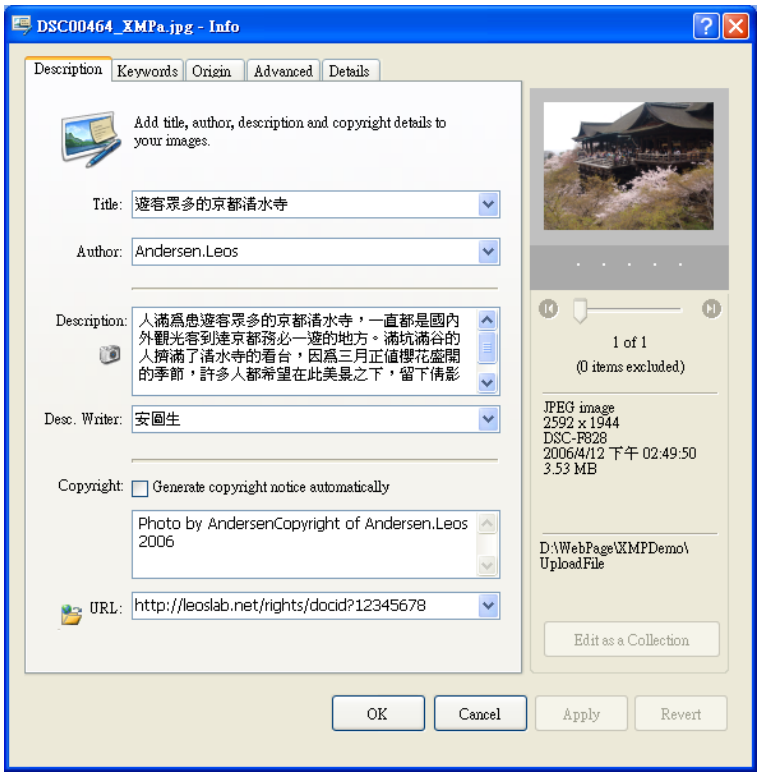

FIG. 11. Microsoft FileInfo Tool.

5. Discussion

In spite of the convenience of applying EMF to digital images, planning and design of the application are not really common in digital preservations. Most of the time, in digital preservations websites, several digital objects can be found in the same metadata. Therefore, in terms of EMF, one metadata link to multi-digital objects is difficult so EMF accommodates one-to-one match design (one metadata links to just one digital object).

According to some research, the following problems may occur in EMF core and architecture design.

5.1. Character-set and encode

Not all operating systems and application software support Unicode or UTF-8. In some non 32-bit operating systems or models, Unicode fits in application software well to deal with data processing and save information as metadata. It is likely to make the previous texts saved in the image files irrevocable and non-retrievable.

5.2. Data limit and file size

Embedded metadata sets up word limits in the columns; texts up to a certain length will not be allowed. This commonly happens to all information systems or database systems, though. All information systems have restrictions on the length of texts.

On the other hand, while a large number of texts and content are entered into digital image files, they will burden the volume of the original files. The overweight contents may cause failure of texting in the process of access to embedded information, or even the image files themselves.

5.3. Multiple and repeatable data

XML structure is used frequently to mark-up metadata in digital preservation. XML structure is characteristic of multi-value and repetitive. It is particularly appropriate for remarks on descriptive information. Consequently, XML files are popular among application projects for digital preservations whereas EMF adopts XML/RDF to make records that makes multiple data fields in Custom File Info Panel difficult.

In XML, data can be annotated as:

```
<Creators>
  <Creator role=”au”>Andersen Leos</Creator>
  <Creator role=”tl”>Cindy Hsu</Creator>
  <Creator role=”il”>Shiro</Creator>
</Creators>
```

In Custom File Info Panel, it is likely that only one column of Creator is multi-valued as below:

```
Creator: Andersen Leos; Cindy Hsu; Shiro;
```

Though multi-value is allowed in one column, the individuality of each creator cannot be shown.

5.4. Metadata security

Security issues in embedded metadata may be attributed to damage or access failure due to encoding, text length or formats. Moreover, security of metadata seems to draw more attention. Adobe unveils the permission to XMP – SDK and API for developers or the 3rd parties to develop XMP-related applications. They aim to promote XMP applications. However, since the permission is open to the public, embedded metadata of digital objects thus becomes easily accessible, editable, amendable and saved.

The structure of Adobe XMP records the whole metadata XML documents using plain text. Only through a simple control bit can information be made retrievable and amended by the system. For example, <?xpacket end="r"?> signifies readability while <?xpacket end="w"?> marks rights to write in. Metadata of files is easily amended.

A proper information system must contain feasibility and reliability. Apparently, the application of embedded metadata should enhance levels of reliability to reinforce security and trust with users.

6. Conclusion

This research proposes a method of combining image files and metadata; as soon as digital archives are loaded in metadata, metadata can be retrieved from files in the process of moving or exchanging files. In the plan of the system, owing to the characteristics of metadata itself, permitted digital files can exist independently from any platform and editing without any information systems. Thus, editing metadata can be customized online or offline in accordance with the will of the teams. The editing organizations can be different from the preservation units.

Once the digital files are downloaded, the metadata can be shared among other organizations or exchanged through Metadata XML extracted from Tools.

The structure design has flaws as well. On the whole, though the Adobe XMP application is not perfect, it is a good way to connect metadata and digital objects. The research intends to examine the feasibility of embedded metadata applied to digital preservation and probe into possible problems, limitation and bottlenecks. Finally, suggestions are proposed for future research.

It is found that the characteristics of digital files enable information to be contained in the files all the way around. At the same time, through a common interface and method, retrieval of the information saved is allowed so as to identify, describe, control, direct, as well as announce copyright of the files. How to make good use of metadata becomes more important. Further, many other types of media formats start to adopt similar embedded methods, such as IDv2 in MP3 and MPEG-7 in digital video. They will be future application areas for embedded metadata.

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