IJDC | *General Article*

Integration of Audio Resources into a Digital Library: The BEIC Case Study

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Abstract

The focus of this paper is on the integration of audio resources with other content types in digital libraries. As a case study, we will present the most recent initiative of the *Biblioteca Europea di Informazione e Cultura* (BEIC), an Italian institution that pursues educational and instructional goals through the realization and management of a multimedia, free access, open shelf library. A new audio section will be added to the already-existing digital archive, allowing users to listen to about 1000 classical recordings in a multi-platform and cross-browser manner. This experience involves a number of heterogeneous fields, ranging from musicology to computer programming, from cataloguing to digitization and archiving. In this paper, we will apply a bottom-up technique in order to provide a generalization of the specific case study, thus suggesting a methodological approach for similar initiatives.

Received 29 January 2015 | *Revision received* 21 May 2015 | *Accepted* 10 June 2015

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The *International Journal of Digital Curation* is an international journal committed to scholarly excellence and dedicated to the advancement of digital curation across a wide range of sectors. The IJDC is published by the University of Edinburgh on behalf of the Digital Curation Centre. ISSN: 1746-8256. URL: http://www.ijdc.net/

Introduction

The *Fondazione Biblioteca Europea di Informazione e Cultura* (BEIC) is an Italian cultural institution established in Milan, 2004. Its main goal is pursuing educational and instructional goals through the realization and management of a new multimedia, free access, open shelf library. The BEIC Foundation aims at devising, supporting, promoting and organizing events and projects of all kinds, including integrated interdisciplinary research on cultural, scientific and social issues.

One of its tasks is to promote European heritage by cooperating with municipal, regional, national and international institutions, and with universities and other cultural bodies as well.

Among the founding members, there are relevant Italian institutions: Ministero dei Beni e delle Attività culturali; Ministero dell'Istruzione, dell'Università e della Ricerca; Comune di Milano; Regione Lombardia; Università degli Studi di Milano; Politecnico di Milano; and others.

The *BEIC Digital Library* (BeicDL) stands out for its selectiveness and the multidisciplinary nature of its collections. Key authors and works in quality editions have been identified by specialists in numerous fields of study. The holdings of major libraries and special collections in Italy and beyond have been drawn on to obtain digital copies of the selected works.

In this way BeicDL makes freely accessible a vast complex of works produced by sciences, arts and humanities, across a timescale that ranges from the ancient world to the modern age. At the moment of writing (July 2014), the digital library is composed of 6300 books approximatively, and it contains about 12 300 records referring to more than 1900 authors.[1]

The BEIC Audio Section

In January 2013, BEIC decided to extend its digital collections by opening a new section on its portal: the *Audio section*. To this end, the *Laboratorio di Informatica Musicale* (LIM, Music Informatics Laboratory) of the Università degli Studi di Milano was contacted.

The original goal was selecting the most relevant composers and masterpieces in music history, and choosing outstanding recorded performances. The total amount of recordings to acquire was fixed to about 1000 albums.

In the framework of this initiative, the tasks that LIM had to carry out were as follows:

1. selection of composers, compositions and recordings through (hopefully) objective criteria, on the basis of expert-driven indications;
2. automatic ripping and recoding of audio and digitization of graphical materials;
3. harvesting of metadata and freely available scores;
4. integration into a software tool already used to manage digital assets;

[1] BEIC Digital Library: http://www.beic.it/

5. design and implementation of a customized player to experience audio tracks.

Each task will be discussed briefly in the following section.

Implementing an Audio Collection

In this section we will describe the key problems to face in order to add an audio collection to an already existing digital library. Our goal is providing helpful guidelines for similar initiatives.

Even if the case study we will analyse is based on the BEIC experience, most of the proposed models and processes can be applied to general cases, since we have adopted international standards and commonly used technologies when available. For those operations that inherently cannot be standardized – such as the selection of music works – we have identified objective criteria based on scientific literature.

It is worth underlining that some implementations depended on the available set-up. For example, in BeicDL the catalogue search is achieved through ExLibris Primo® and the digital library management software is ExLibris DigiTool®. However, even if the framework is proprietary, it features a modular open architecture developed in partnership with top-tier university libraries. Such technologies, often considered *de facto* standards in the field of digital libraries, support flexible metadata schema, such as MARC, Dublin Core, the Metadata Object Description Schema (MODS), and the Metadata Encoding and Transmission Standard (METS). For further details on these formats, please refer either to the official documentation or to scientific works such as Weibel (1997), McClelland (2003), and Guenther and McCallum (2003).

Selection of Audio Materials

The selection of a suitable set of audio materials was the starting point of the project. The initial requirements were as follows:

- to cover the masterpieces of classical music as regards composers and compositions, ranging from ancient to early 20th century music;
- to choose outstanding recordings, either for the importance of the performers or for their historical, musicological and technical relevance;
- to provide multiple performances for the most important music pieces;
- to limit the number of purchased albums to about 1000.

Needless to say, this kind of activity could be a very subjective one. Defining who are the most important composers was the first hard task: in fact, some are universally recognized as a genius (e.g. L. van Beethoven and W. A. Mozart), some were very prolific (e.g. G. P. Telemann and A. Vivaldi), some were a key composer for a given genre and style (e.g. C. Monteverdi and G. P. da Palestrina), and so on. Probably, musicologists would never agree on a common set of "important composers". Furthermore, this was only the very first step of the process, necessarily followed by the selection of relevant compositions for each composer and by the selection of outstanding recordings for each piece.

It would be fair to say that the selection process for the collections hosted by BEIC is a subjective one. Indeed, their mode of operation is to follow the recommendations of experts and specialists in numerous fields of study in order to identify key authors and works in quality editions, as declared in the official Web site. However, the solution implemented by LIM staff was to rely on specialized literature – in particular Rye (2008), Jolly and Threasher (2013), and Libbey (2013) – and to adopt the following algorithmic approach.

Composers, pieces and performances were picked in this order of priority, combining the data coming from all the mentioned sources.

In order to choose composers, we selected only those whom the authors had listed in all the books, thus obtaining the sub-set C of composers.

As regards music pieces, we decided to include all the compositions belonging to any composer c in C that are listed in at least one of the texts, thus obtaining a set of pieces P_C. For any piece p in P_C, let r_p be the total number of references to p in the texts.

From the following statements:

- the total number of texts is $n = 3$;
- each piece can be referenced either zero or one times in each text;
- each piece is referenced in at least one of the texts;

it follows that $r_p \in \{1, 2, 3\}$.

For the sake of clarity, an example is called for. Let us cite some works composed by S. Rachmaninoff. *Rhapsody on a Theme of Paganini, Op. 43* is cited only in Libbey (2013), *The Isle of the Dead* in Libbey (2013) and Rye (2008), and finally the *Symphonies* in all three books. Consequently, for these pieces we selected one, two, and three recordings respectively.

The last problem was picking some of the suggested performances. Sometimes the texts agreed about a specific edition or performer, thus suggesting a shared candidate. However in most cases the final choice depended on a great number of factors, including availability on the market.

Please note that this process can be generalized, extending it to n bibliographic sources (in the mentioned case $n = 3$) and providing – if necessary – a weight to take into account their authority.

At the end of this step, the BEIC project included 135 composers (38 from Italy) and 410 compositions.

Processes and Formats for Digitization, Ripping and Recoding

After selecting a list of materials, the next step is to start a digitization campaign and choose suitable formats in which to encode documents. In our case study, audio (CD tracks) had to be ripped and graphic materials (covers, booklets, etc.) had to be digitized. Other content types could have been added, such as full-text transcriptions of booklets, but they would require a considerable amount of work.

For audio data, we identified three quality levels, implying different file formats and corresponding to different use cases:

1. *High quality* – Suitable for the preservation of original audio information. Formats can be raw, uncompressed, or compressed in a lossless manner. In the BEIC project,

CD-DAs are physically stored in a safety vault, so the production of high-quality files is not required.[2]

2. *Medium quality* – Conceived for most applications, including on-line listening. Formats can be compressed in a lossless or lossy manner, but in the latter case audio quality should be preserved. Since the BEIC audio player had to be integrated into an HTML5 Web interface, we produced both MP3 and OGG versions at 320 kbps in order to support all the major browsers. This result was achieved through an automatic recoding process, performed by suitable shell scripts.

3. *Low quality* – Intended for preview listening only. Suitable formats are lossy and characterized by a high compression rate. Audio tracks can also be trimmed to a limited number of seconds. For instance, in BeicDL low quality implies 30 s MP3 and OGG files at 128 kbps.

If many digital media have to be ripped – that is, the contained data must be migrated to files – the best solution is an automatic one where available. For instance, there are several models of *disc autoloader* available on the market. Usually their goal is burning many times the image of a single CD or DVD, and in that case they are loaded with a great number of writeable media. In this context, however, these devices must be loaded with the set of media to acquire, thus acting as a sort of jukebox. In the BEIC project we used an Acronova Nimbie robotic device with a capacity of 100 discs. Unfortunately, the automatic solution is not available for most analogue media, such as vinyl discs.

Graphic contents had to be acquired as well, including the front cover, back cover, booklet and the top side of the disc (see Figure 1). Once again, a high-quality version is not required if the physical media are safely preserved, the materials are not subject to physical, chemical or heat damage, and the digitized images will not be used professionally.

In the framework of the BEIC project, the suitable file format for online display – what we have defined as medium quality for audio – is low-compression JPEG. The generation of thumbnail versions, corresponding to low quality in the list above, was automatically performed by the ingestion system adopted in BEIC.

Because of the great variability of sizes and shapes, in general the acquisition process cannot be automated. Moreover, professional devices are required, since standard A4 scanners are not sufficient to digitize most materials due to the maximum supported size and scanning quality. As regards the present case study, digitization of graphical materials was achieved on an Epson Expression 1640XL scanner. Originally acquired in TIFF format, 32 bits per channel, 600 dpi, they have been downgraded to high-quality, low-compression JPEG, 8 bits per channel, 300 dpi. The average size of the resultant files is about 1.5 MB for discs, 5 MB for front covers (including the inner side) and 3 MB for back covers.

By the end of the BEIC digitization campaign, 688 albums and 1479 media had been acquired, thus producing 81376 audio files (4 versions per track, i.e. MP3 and OGG at both medium and low quality) and 3656 image files.

[2] Please note that BEIC is storing commercially-produced CDs, characterized by a more permanent technology than optical media such as writeable CD-ROMs and DVD-ROMs. Writeable media are not considered suitable for preservation by IASA and other authorities such as the BBC and the Library of Congress since they can be easily damaged and have a poor suitability over the long term.

Figure 1. A set of graphical materials related to a recording.

Metadata Cataloguing in DigiTool

The BEIC digital repository has adopted ExLibris products for the management of its catalogue and digital objects. In particular, these tasks are achieved through ExLibris Primo (see Figure 2) and DigiTool, respectively.

In DigiTool, information about digital objects can be loaded through XML-based files encoded according to METS specifications. The METS schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, expressed using the XML schema language of the World Wide Web Consortium. The standard is maintained in the Network Development and MARC Standards Office of the Library of Congress, and is under development as an initiative of the Digital Library Federation (McDonough, 2006).

BEIC *Audio section* contains music albums, which are aggregations of heterogeneous digital objects – namely audio tracks and images – characterized by a standard set of metadata. The granularity of such metadata can be at album, single medium, or track level, and this association can vary from album to album. For example, the composer can be unique for an album made of n discs (e.g. Giuseppe Verdi for *Aida*), can be unique within a single-disc album (e.g. Giuseppe Verdi for *Aida Highlights*) or can change from track to track (e.g. Giuseppe Verdi for some tracks extracted from *Best of Opera*). In this sense, the correspondence between albums and compositions is complex. In fact, a given composition can

- be a sub-part of a disc, either a single one or part of a collection;
- fill a single medium;
- fill a CD boxset.

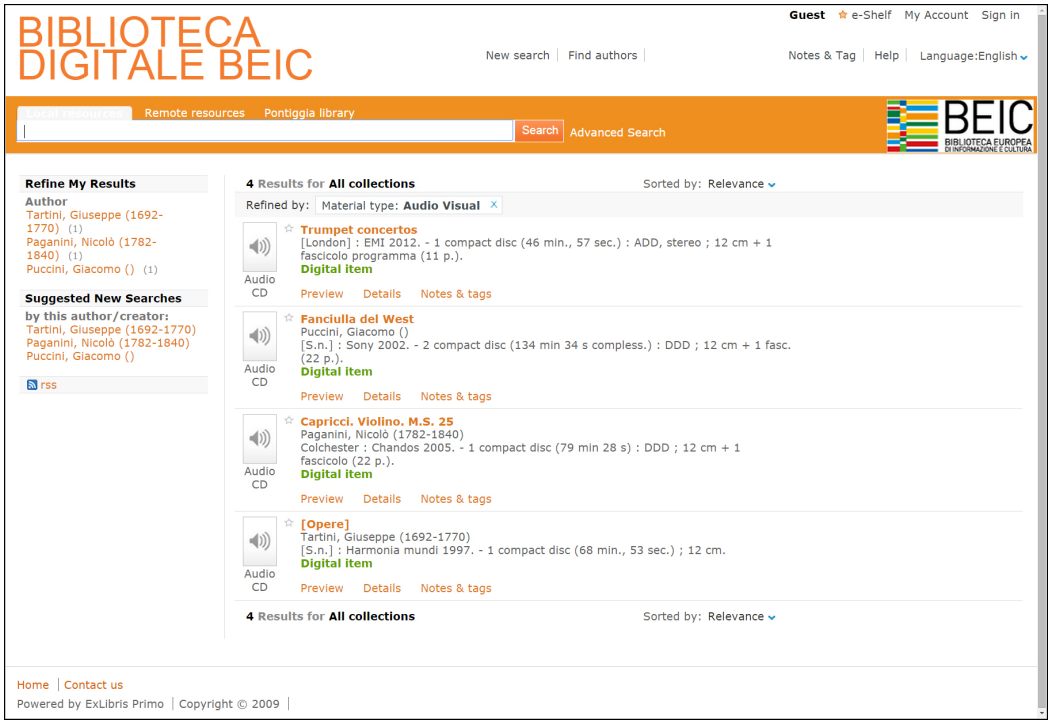

Figure 2. ExLibris Primo result page for audio and visual contents.

The solution is to provide two different hierarchies for physical objects (collection, single medium, track) and works (opus, composition, single movement) respectively, and a way to mutually map such entities.

In the BEIC project the aim is to provide an album-oriented description, like in Amazon or iTunes. Consequently, a METS file for each album has been created. The internal structure of METS files allows one to link specific metadata descriptors to albums as well as to sub-parts. For example box-related and CD-related images have been linked to boxes and CDs respectively. Similarly, artists have been acknowledged for their performances either at album or at track level. METS is an XML-based format, consequently too verbose to be reproduced here. However, any bibliographic entry of the BEIC digital collection has an associated METS file which can be opened from the Web interface.[3]

Metadata entry is a cataloguing and musicological activity, consequently in the BEIC project it has been assigned to experts in the field. Please note that when the project timeline is under discussion, it is necessary to consider the difference between the duration of the digitization/ripping phase, usually shorter when automatic tools are available, and the duration of the cataloguing phase. The former step in BEIC required 6 months to generate all the audio and graphical contents, whereas the latter one – started only after the conclusion of the digitization phase – is currently a work in progress and it has produced a limited number of complete records so far. In projects where the intervention of musicology experts is not feasible or required, cataloguing could be automated as well. In this case, publicly available authoritative metadata sources such as *Gracenote*, or crowd-based initiatives such as *freedb*, could be of great help.

[3] Example BEIC METS file: http://131.175.183.1/webclient/MetadataManager?pid=5676905&show_xml=true

Even though Digitool has been designed as a software tool to manage and showcase digital collections in general, usually it is applied to text and graphical content repositories. Consequently, DigiTool natively supports hierarchical structures potentially made of multiple levels (e.g. a journal series, made of volumes, issues, and finally papers), which is suitable for most cases. In this project, however, we had some additional goals, for instance the one of simultaneously supporting different hierarchies (album-media-track and composition-movement) to classify music information. Metadata management in DigiTool has been adapted in order to support custom cataloguing oriented to audio tracks and albums through the adoption of METS.

Cataloguing is an activity easier to perform when the environment is completely under the developer's control. For instance, if metadata are archived in a custom Entity–Relationship (ER) model, it is sufficient to structure the database schema in order to support any required granularity and relationship among entities.

Designing the Web Interface

The final goal of the project is to provide the visitor of BEIC portal with a Web interface integrated into the existing environment but specifically customized for music albums. Audio files are already natively supported by ExLibris DigiTool, but opening such digital objects would invoke a standard player showing only the object itself and whose interface depends on the browser in use. In contrast, the idea for the BEIC portal is to show a complete representation of the album, containing all the available metadata and graphic materials, and with the possibility to jump from a track to another. This result can be achieved through an ad-hoc parsing of the XML file encoded in METS format. The player has been implemented through standard technologies and languages, namely HTML5, Javascript and PHP. In this way, the resulting solution is cross-platform and compatible with all browsers that support the HTML5 `<audio>` tag.

Figure 3 shows a screenshot of the user interface. It is possible to recognize mainly 3 areas:

1. The upper part contains metadata and images common to the album (either a single disc or a multi-disc box).
2. The central part is devoted to the list of tracks and recalls from a graphical point of view the back cover of CDs. In addition, it contains links to load the track in the audio player and to open the corresponding score in PDF format, when available.
3. The lower part embeds the audio player with a set of standard controls and the metadata related to the current track. Please note that also the advancing bar can be clicked in order to re-synchronize the audio performance.

The interface design has been inspired by other available Web players, thus supporting common media controls, detailed metadata display, automatic progression from a track to the next, and so on. As mentioned above, the media player has been integrated with the already available DigiTool environment, and navigation among similar contents has been made possible by the catalogue query interface.

An important problem to address in this kind of initiative is related to copyright issues. In fact, in general terms recordings fall under authors' and publishers' rights and specific

 doi:10.2218/ijdc.v10i2.345

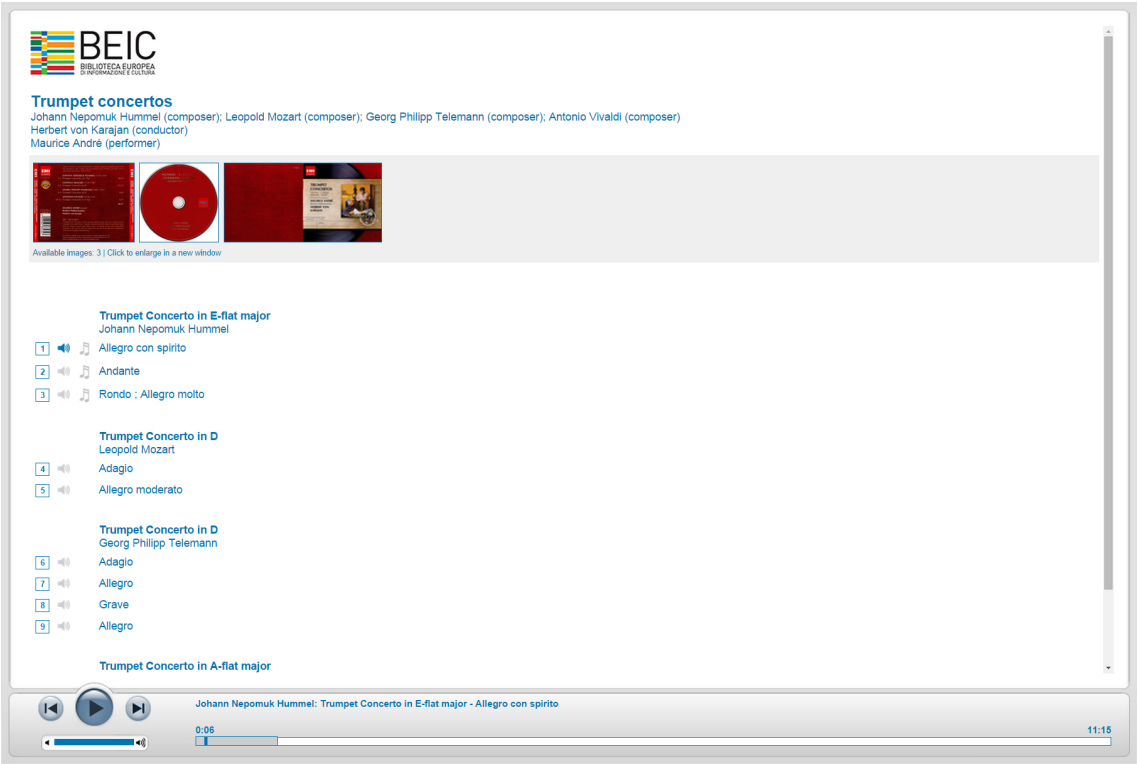

Figure 3. Screenshot of the customized Web player.

agreements should be established with these parties in order to broadcast their works. An in-depth discussion of this matter clearly goes beyond the scope of this paper, but in the context of the BEIC project, the copyright issue has been addressed as follows.

One method that has been employed to protect materials is intrinsic: by providing only audio excerpts and low resolution graphical materials, users never have access to original high-quality documents. For instance, the so-called *medium quality* cited above is sufficient for a satisfactory Web experience but does not allow a professional-quality download of digital documents. Besides, multimedia objects are simply streamed to clients and they do not reside on local machines. Additionally, it is possible to distinguish authorized users from guests: in this way, the Web interface can broadcast user-tailored materials to each client. For instance, the BEIC interface provides either low-quality graphical files and 30 s audio files or high-quality images and complete tracks depending on the client IP address.

Please note that more advanced features could be implemented, such as a quick comparison between different performances belonging to different albums. Even if technically feasible, this idea was rejected by BEIC staff because – for consistency with the pre-existing contents – they decided to show search results only inside the catalogue environment.

Conclusions and Future Work

In this paper we have discussed how to add an audio section to a traditional digital library. The main aspects of novelty are the methodology to select the album set, the

implementation of an ad-hoc HTML5-based player and the integration into an already-existing digital library environment. The BEIC project has represented the test bed to validate the effectiveness of the proposed solution.

As regards future work, many aspects can be cited. First, the solution could be scaled to an arbitrary number of purchased albums and musicological sources, and also adapted to other music genres and collections. Second, advanced features such as on-the-fly comparisons among performances could be implemented. Finally, other Web-based technologies could be employed to implement score following and audio-visual synchronization. An example is IEEE 1599 format, an international standard to provide a comprehensive description of music-related materials (Ludovico, 2013).

Acknowledgments

The authors wish to acknowledge the BEIC staff for their contribution to this project, and in particular Antonio Padoa-Schioppa, Danilo Deana and Chiara Consonni.

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