14 Digitization of Musical Sources: An Overview

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Abstract

Digitization of musical source material is not a new technique. Yet it has only begun to emerge in the field of music scholarship in the past two years. Declining prices and increased functionality of equipment and software have facilitated this transition. This article presents a brief overview of the basic essentials of digital imagery and gives a brief introduction to graphic databases and their usage. It introduces a series of articles that concern widely varied uses related to both printed and manuscript materials from the fifteenth century through recent decades.

Supplementary images are viewable on the World Wide Web through the link *www.ccarh.org/publications/cm/12/*

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Digital media occupy a central position in most art-related disciplines, although they still have not seen widespread use in mainstream music research. Since so much of the representation of music is graphically based and so much implicit historical information lies in graphic format, the need for digitization of this material would seem to follow naturally. However, the field is still largely mired in microfilm.

For a modest investment, it is quite possible to prepare a collection of graphic images, construct a database, and maintain these images in a solid, compact-disk format. No long-term investment in either equipment or time is necessarily required. Resulting products may be stored for controlled reference on compact-disk media or placed on the World Wide Web for universal access. Image collections may also be licensed or sold, depending on the copyright status of the material. In one of the following cases, crude images useful for identification are available without cost, while access to high-resolution images is controlled to accommodate licensing restrictions imposed by source-owners.

The advantages of digitization are apparent. Computer-stored image technology can help to record and preserve old images before they disintegrate forever. Digital media can store vast amounts of data for archival purposes, allowing more people more access to more data. Graphic databases can provide researchers with a tool for retrieval and structured query that is not easily available through conventional means. It may be only the fear of computing complexities which keeps this rather basic technology under-developed.

This overview, which is by no means a definitive listing of available technologies but does describe a working model, offers a digitizing (scanning) and record-keeping system for digital imagery.

14.1 The Digitization Process

The digitization of images is the process by which a computer-based (digital) representation is generated from original source material, whether textual or graphic. More properly, it is the sampling (akin to copying, by the scanner) of analog data (source material) by some type of recording device (e.g. a scanner) resulting in digital data (0's and 1's interpreted by a computer processor) which can then be repeatedly interpreted and represented in analog form by a computer (i.e. a picture on a computing monitor). A good digitization is always somewhat inferior to its analog source, since sampling necessarily provides finite representations of inherently infinite source data, but this inferiority is usually imperceptible.

14.2 Image Acquisition

14.2.1 Methods

Several different techniques are utilized in the production of digitized images from analog sources. The most efficient manner of achieving maximally accurate digitization requires direct contact between the original source material and the scanning device. However, because many materials are fragile or not directly available to the would-be user, this is often not possible. Thus, different intermediary images are sometimes produced for later scanning. Depending on the sources, material may be (1) photocopied, (2) traced, or (3) photographed with a conventional 35mm camera utilizing either print or slide film, and these resulting intermediaries in turn function as source scans. Each of these pre-scan processes is appropriate for a variety of applications and ultimately determines the quality of the resulting digital image. Obviously, the further removed an image is from its source, the less accurate is its representation, though there are certain applications such as text scanning where image quality is not so critical.

Photocopying is generally used for creating intermediary images in situations where scanning is unavailable or impractical. This technique is most acceptable for producing copies of text for scanning and/or later processing by optical character reading programs (e.g. *Omnipage*) which convert graphic text to ASCII code, portable to any word processor.

Tracing involves the use of a flat panel with a pen to trace the outlines of material affixed to the panel. The path inscribed by the pen is readily analogous to a series of [*x*, *y*] coordinates, and these are easily interpreted by the computer and represented in analog form on the monitor.

When maximal accuracy is needed and the source material is fragile, conventional 35mm photography is the easiest and best choice for producing intermediary pre-scans. Print film can produce vivid and clear analog pictures, and slides provide even better results. Many photographers prefer slide over print film because the sharper, tighter grain of the slide is superior to the rather static nature of photographic prints.

14.2.2 Costs

While just a few years ago the quality of images produced by reasonably priced equipment was not acceptable, recent upper-end equipment in the general consumer market is performing favorably. The use of a digital camera obviates the need for any further digitization, since its end-product is itself a digital image. The better digital cameras are remarkable in quality, but high-end professional models are expensive. Digital technology is constantly improving and it is conceivable that within the first decade of the twenty-first century the quality of digital will come to equal analog, at an affordable price.

The process of scanning source or intermediary material is straightforward. Numerous flatbed models are widely available for capturing sheet-style images; their operation is similar to that of a common photocopy machine. Roll-fed scanners are inexpensive alternatives when lower quality and resolution is acceptable. Slides and negative film may be processed with a variety of slide scanners (for example, a slide scanner was used to digitize many of the images referenced in this article).

Drum and hybrid flatbed scanners produce the best results, though they are more expensive. Software applications accompanying any of these scanners lead the user through the process of copying a source image and producing a digital representation. These applications usually also interact with the image-processing application *Photoshop*, which can be used for further processing beyond the basic scan. While the basic digitization process is quite simple, working within *Photoshop* requires practice and experience. However, basic scans with no further processing are usually of acceptable quality, particularly if the source image or its intermediary is clear and distinct.

14.3 Image Resolution

Image resolution (referring to the amount of information available per unit of area) is an important consideration; its parameters may be varied in most scanning software. The dots-per-inch (dpi) metric affects the size of the scan file: the higher the resolution, the larger the digital-image file. For textual scanning and optical character reading, high resolution is not necessary. For graphics and in situations where sharp detail is important, a high resolution may be needed. It should be noted that an analog computer monitor *displays* images at 72 dpi. Thus all images, regardless of their resolution, will appear similar on the screen.

High-resolution images will occupy more disk space and will produce clearer close-ups. Low-resolution images will occupy less disk space, and close-ups may appear blurry. Whenever possible, higher resolution is the better scanning choice for archiving, as it ensures the recording of the maximum amount of data and detail. Resolutions of 2000-2500 dpi will generate good image quality with room for some close-ups. More expensive scanners (i.e. drum and hybrid models) can produce images with even higher resolution. These produce very large image files; at the highest available resolutions the "dots" of the scanned image may approach a 1:1 ratio with the grain of the film. At this point, a digital image is virtually equivalent to an analog image.

14.4 Storage

As images are digitized, they must be stored on media, such as large diskettes, hard disks, or compact disks. As with any computer application, the routine backing up of data is extremely important, so the production of multiple archive scans is advised.

A variety of storage options exists. If the sum of the sizes of all images in a collection is between one megabyte and one gigabyte, an Iomega Zip disk (currently available in 100-megabyte, 250-megabyte, and 1-gigabyte sizes) is a popular choice for a storage medium. It seems likely at this writing that the zip disk will be a widely supported option in industry and academe for some time to come.

Permanent archival storage is best achieved with the recordable compact disk (CDR) or digital video disk (DVD) ROM; both are easily available on desktop computer systems and the latter is increasingly common on laptops. Each standard CDR has a total data storage capacity of about 720 megabytes. DVD ROMs are similar; they will hold even more than 720 megabytes. Care should be taken to keep the lower-cost CDR away from direct sunlight, as this can sometimes erase data.

14.5 Creating and Managing a Database of Images

While it may seem most convenient to store digital images on storage media with no logical structure, this arrangement precludes efficient long-term access to and use of the material. A structured database of images may be utilized to organize the images and facilitate various research possibilities. Selection of an appropriate database, however, is problematic. Many commercial products are available—too many to mention here—and many researchers are tempted to produce their own databases.

How does one choose database software? While a professionally conceived high-end database has its advantages, the cost is likely to be prohibitive and the end results may be no more useful than a lower-cost alternative. Off-the-shelf products have many advantages; besides their affordability, they are generally easy to use and provide excellent results. It is, however, important to consider the desired end-product. Are the images to be marketed? What is the audience for the product? What kinds of computers will access the data? That is, does the product need to support cross-platform access? These questions were probed extensively in the development of some of the projects reported here. It was found that the answers limited the range of choices significantly.

14.5.1 Software Management Issues

For the Berg Image-Database (images of the music of Alban Berg) developed by Patricia Hall, the original conception utilized *FileMaker Pro*, a simple relational database available on both the Intel and Apple Macintosh platforms. The product was easy to use, widely available, and supported multiple platforms (PC and Macintosh).

While it was relatively easy to create an attractive interface with fields for source images, thumbnails, and every parameter descriptor imaginable, *FileMaker Pro* did not function well as a graphic database. Image redraw (the time needed for the image to appear on the monitor) was too slow, even on fast computer systems, and the programming environment was cumbersome with graphics. Furthermore, in order to use this product, all end-users of the database would have to own a copy of *FileMaker Pro* or a license for a runtime version of the software (an abbreviated substitute for the full application).

This situation forced a reconsideration of the database. It needed to be cross-platform. It did not need Web capability, since the data were not to be publicly presented (a CD-ROM available by license was the envisioned method of distribution). It needed to be inexpensive and moderately easy and efficient to use. It had to preserve the media assets in any resolution (up to the maximum scanned dpi). Most important, the product had to provide a low-cost runtime option, since any distributed product had to be stand-alone.

The graphics database entitled *Cumulus* (published by Canto Software in San Francisco for the Mac and Windows platforms) was chosen instead; it met all of the requirements listed above. Though its field descriptions and general layout are not as elegant as those available in the *FileMaker* database, its overall advantages more than outweigh the disadvantages. With *Cumulus* source images are catalogued according to type, and the database user may add virtually any number of category descriptors. In turn, users can search and sort based on these categories; they can make queries and then compare results to those of other searches in order to establish relationships between data. An analysis of these relationships is a subject unto itself. The runtime module available from Canto is cross-platform and may be freely distributed (after payment of a modest one-time fee). Certainly, technologies will evolve and *Cumulus* will someday be obsolete. However, the principle of organizing graphic assets in a searchable graphic index is an archetype which will manifest itself in computer software products for many years to come.

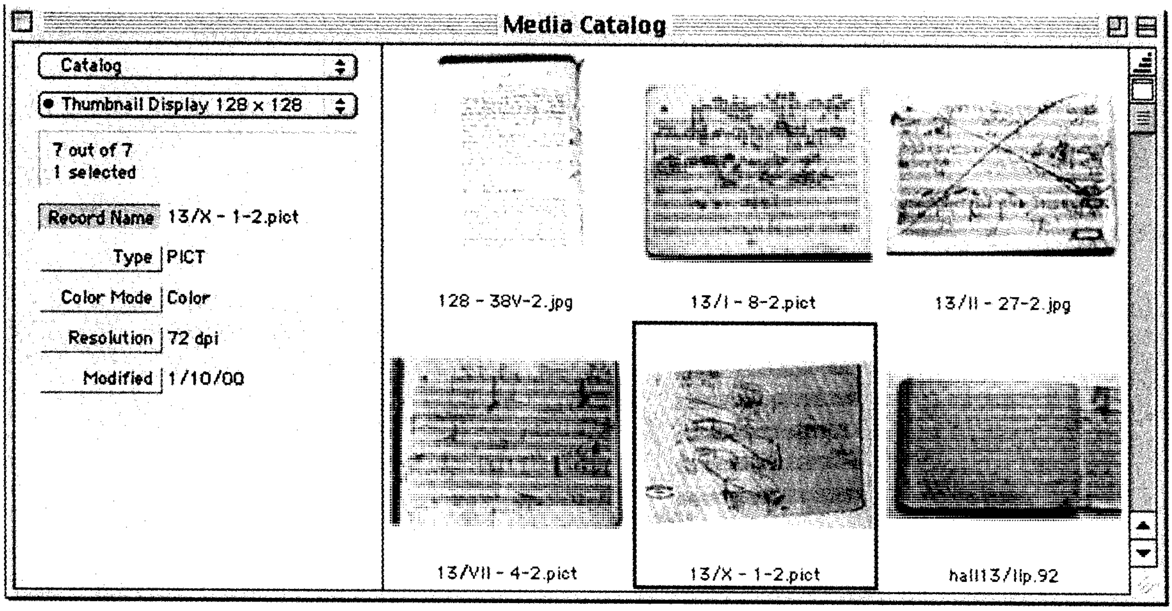
Figure 1 shows the main *Cumulus* window with several images. Clear thumbnail images created from the source images by *Cumulus* form a visual index. Parameters are understandable and easy to use. The screen layout is fairly simple. Query commands with all standard functions are readily available in the menus. The runtime version is very similar, though it lacks the ability to modify and augment existing databases. (For further information on the content, see Patricia Hall, "The Making of an Electronic Facsimile: Berg's Sketches for *Wozzeck*" in this issue.)

Newer versions of *Cumulus* are purported to offer new functionality in the area of field descriptions. This will help to improve their somewhat stale presentation in the current version.

14.5.2 Access and Distribution Methods

Once a database is complete, distribution is perhaps the final concern. Assuming copyrights are cleared, a choice must be made regarding access.

Figure 1. The *Cumulus* window, as used in Patricia Hall's image database of the music of Alban Berg. The images are captured in color and may be viewed in color on the Web.



The Web is a tremendous environment for providing universal access, yet it is difficult to protect intellectual property, particularly when this is graphic imagery. The stand-alone CDR has the advantage of being a product which may be distributed, and whose production can be controlled in a manner similar to a printed book. This may be more appealing to publishers and those holding the rights to the source material, although many book-producers dislike the physical process of adding CD-sleeves to jackets, while libraries holding rare materials and publishers of musical scores are increasingly finding methods of limiting Web access to designated users (see Anthony et al., "The Electronic Dissemination of Notated Music: An Overview" in this issue). Individual tasks and circumstances will dictate the appropriate choice.

Digital media continue to play an ever-increasing role in academic study. A range of ways in which they are currently used are represented in the following articles. The graphic database is one of many valuable tools for those studying pictorial data. Since the cost of most of the technology is no longer excessive, it appears that in little time all this will become commonplace.