# Integrating Paper and Digital Music Information Systems

Abstract

Traditionally musicians have stored and retrieved music scores using paper-based systems. Many musicians have built up personal libraries of music books, compositions, arrangements and sheet music. The acquisition or creation of documents is straightforward, but the retrieval or modification of scores is hindered by the inflexibility of the paper medium. A digital music library would have a number of benefits, including convenient retrieval (instead of searching through piles of music), ease of processing (such as part extraction), and communication (sending electronic copies to other performers). However working with digital documents also poses significant barriers for users more familiar with traditional paper documents. In this paper we explore the relationship between the paper and digital domains, and the possibility of allowing easy conversion between the two to allow documents to exist in both domains and be processed in whichever domain is the most convenient.

We begin by proposing a three-state model that provides a framework for reasoning about the different domains. Then we report on a survey of musicians to determine the kinds of retrieval and processing tasks they carry out, and their preferences for carrying out these tasks in each domain. We then report on a system in which color manuscript is used to simplify the transition between paper and digital media.

Three-state model. Rather than just use two states of a document (paper and digital), we propose a model that divides the digital state into two: image data and semantic data. Figure 1 shows the resulting three-state model, with transitions showing how data can be converted from one state to another. Digital image data is typically a bitmap representation of the pixels, whereas the digital semantic data stores information about pitch and rhythm.
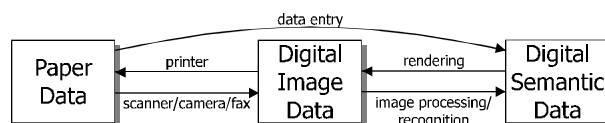
Figure 1: Three-state model of data

A document may well exist in all three formats at once. For example, a score in a musician's library might be scanned as a digital image and stored on a portable device, but also be recognised as best as possible to allow semantic information to be stored for convenient retrieval. This model is used for text in the Adobe Acrobat Capture system [Merz 1997], which can be used to put a paper document on-line in a form displaying the original scanned image, but 'hiding' an OCRed version behind it to allow searching and copying of the text. The more accurate the recognition, the more useful the retrieval process will be. Retaining the image data prevents mistakes in recognition being reflected in the displayed version of the document.

How musicians organise documents. We designed a survey in order to assess how digital techniques could aid musicians with music information management. We were interested in musical activities of all kinds including composition, arrangement, performance, teaching, musicology, recording, accompanying, transcribing and so on. We asked some 40 musicians about the tools that they use, their working procedures, difficulties that they face, and ways that digital storage and retrieval might be applied.

The survey identified a number of existing problems that with the use of computers for managing musical documents. These included

- The cost of computer hardware and software.
- Viewing music on a relatively small computer screen.
- Using computers can cause a loss of inspiration and creativity.
- Loss of efficiency because it can take more time to enter music.
- The long learning curve required by some music software.
- Software compatibility (between versions and different systems).

Hand-writing music on paper first also poses problems. Half of the participants write music by hand, and some then further develop or arrange their idea on the computer, reflecting the flexibility of the digital medium. We have also observed that another problem with paper documents is the choice of writing implement. A pen is better if the music is to be photocopied and distributed, but a pencil is more flexible for correction of errors.

We were also interested in which criteria are most useful for searching for a piece of music in personal collections, music libraries or music shops. In the future the distinction between these is likely to be blurred by digital libraries. The survey showed that composer, title and instrument would be the most popular criteria for searching a digital music library.

We also asked the musicians to suggest improvements to existing music information systems. One musician surveyed pointed out the difficulty of scanning bound sheet music and books. Many of the musicians surveyed would like a page turning device. Another problem raised was the unreliability of scanning and recognising hand-written scores and old imprints. Even a system that is accurate 99% of the time could have an error in every few bars of a complex piano piece. The time taken to find and correct such errors may not be much less than the time to enter the music correctly by hand in the first place [Hewlett and Selfridge-Field 1994].

Acquiring hand-written music. From the surveys it was clear that composers and arrangers would benefit greatly from a system that allows them to write music by hand and later transfer it to the digital domain. The recognition of handwritten music is difficult, but if the writer knows that the music will be transferred to a computer at a later stage, then the manuscript and notation can be adapted to increase the chances of this being done accurately.

One approach is to use color on the manuscript to simplify the task of separating symbols from the stave line [Lin and Bell 1999]. A major source of error in OMR systems is trying to determine the shapes of objects superimposed on a stave. A simple and effective way of using color is to print the manuscript lines in a color (such as red), so that color as well as position can be used to distinguish any handwritten symbols. Since inexpensive color inkjet printers and color scanners are available and widely used, this method is readily available to any user who has access to a fairly conventional computer setup.

Conclusion. From our work we conclude that there is a demand for merging the paper and digital domains for musicians who would like to be able to take advantage of the ease of use of paper documents, and the flexibility and retrieval properties of digital documents. Giving composers and arrangers the option of working with pencil in the paper domain eliminates the cognitive hurdle of using software while engaged in a creative endeavour. The survey has identified a number of features that would be useful in systems that operate in both domains. By using colored stave-lines the conversion to digital semantic data is provided with extra information to help with the accurate removal of stave-lines, and to help identify special symbols.

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Suggested Readings

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