Towards a Digital Document Archive for Historical Handwritten Music Scores

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Abstract. Contemporary digital libraries and archives of music scores focus mainly on providing efficient storage and access methods for their data. However, digital archives of historical music scores can enable musicologists not only to easily store and access research material, but also to derive new knowledge from existing data. In this paper we present the first steps in building a digital archive of historical music scores from the 17th and 18th century. Along with the architectural and accessibility aspects of the system, we describe an integrated approach for classification and identification of the scribes of music scores.

1 Introduction

Handwritten music scores were a way to record, copy and disseminate music during the late 17th century until the beginning of the 19th century. There exist large collections of such music scores in libraries, archives etc. around the world. The information encoded in these music sheets, such as melody, title, time and place of origin, composer and scribe is of great interest to musicologists. Some of these data are often not found in alphanumeric form in manuscripts, but have to be derived analyzing other document features. Complex typographic and visual features such as handwriting characteristics, water marks etc. are used in practice for the analysis.

This paper represents the latest results from the ongoing project "eNoteHistory", realizing a digital archive for a collection of about 1000 historical music scores from the 17th and 18th century, property of the Library of the University of Rostock. Apart from the scanned score images we store a considerable number of corresponding metadata such as bibliographic and feature data, reflecting the diverse aspects on the content of the manuscripts. We employ full-text, structural and feature-based retrieval techniques to provide complex searching possibilities for different user scenarios. So far our system does not differ to a great extend from existing digital music archives, such as Meldex[1] or DIAMM[2] and many others. However we see the novel challenge of our work in the design of an effective approach for combining the various data in the digital archive to extract new information of interest to the musicologists and in

[1] http://www.nzdl.org/fast-cgi-bin/music/musiclibrary

[2] DIAMM – Digital image archive of medieval music, http://www.diamm.ac.uk/

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particular to identify the scribes of the manuscripts. As classification base we use the handwriting characteristics of the scribes. We have defined a so called Feature Dictionary data structure, resembling a systematisation of the external knowledge used for the description of handwriting characteristics. Currently we develop algorithms for building classes for identifying music scribes based on these features.

2 Architecture and User Scenarios

The digital document archive is implemented using object-relational database system (ORDBMS) techniques, provided in the IBM DB2 UDB environment, offering extensions such as user-defined types, user-defined functions, XML-, text- and data mining-extensions. The advantages of ORDBMS are discussed in [5]. The document workflow considered by the system design is illustrated in Fig. 1.

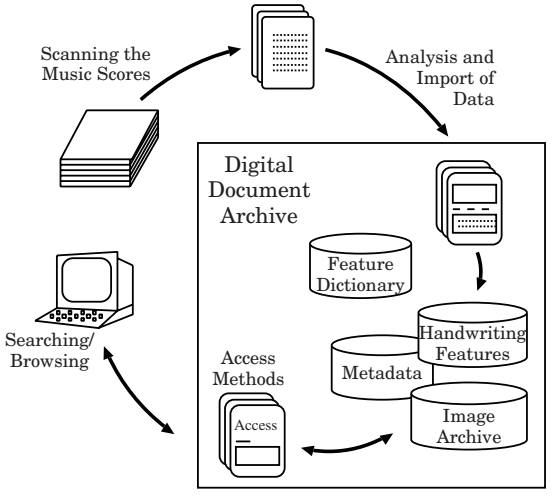

Fig. 1. Digital Document Archive Workflow

The first steps in designing the digital library as suggested in [6] were to define the sources of material and the required data models. We have identified the following groups of material: scanned music scores, corresponding metadata and feature data from the handwriting analysis. The scanned *music scores* build up the image archive. The image attributes and characteristics are also included in the image archive data model to provide enough information for later image processing, browsing or displaying. The *metadata* includes bibliographic data, descriptions of the documents and works, place and time of origin, composer's name etc. These data exist in LaTeX format and is the result of a scientific work published in [3]. In the produced material the RISM[3] database for historical music manuscripts has been referenced and links to it are provided in the metadata schema by shelf mark references. We have defined a relational data model to represent the semi-structured text data. Then we extracted the

[3] RISM - Répertoire International des Sources Musicales, http://rism.stub.uni-frankfurt.de/

content of the LaTeX sources by parsing and transforming the LaTeX document elements and items into XML structures. The XML structures were afterwards mapped to the relational database schema. Employing Text- and XML-based access structures and mechanisms in the ORDBMS provides enhanced possibilities to store, update, retrieve, browse and represent the metadata.

The third group of source material comprises the *handwriting features*, generated from the analysis of the music scores. The extraction and determination of handwriting characteristics from the manuscripts requires experts' knowledge, which is supported by a predefined Feature Dictionary, stored and maintained also in the database. The Feature Dictionary data structure comprises a set of classification trees, where each tree represents a single feature, such as a note stem form, clefs forms etc. A node in the tree corresponds to a certain expression of a feature, represented by a pictogram and a description. A musicologist will be able to browse these trees to find the best matching feature expressions for the analyzed document. Thus the handwriting specific features are stored in the database along with the corresponding images of the scanned manuscripts. These features can be defined on different levels: for a manuscript page, for a whole manuscript, or for a single scribe. The final aim is to be able to gather enough representative material to build classes for all scribes of the analyzed collection. To each class a unique handwriting signature will be appointed, represented by a set of handwriting feature vectors. Therefore we currently implement and evaluate clustering and classification functions using the DB2 Intelligent Miner for Data. A second approach for handwriting feature extraction and scribe identification will be implemented incorporating Optical Music Recognition (OMR) techniques, which are currently in an advanced phase of development and testing. Recent results from the OMR study have been published in [1]. The handwriting characteristics, which are the output from the OMR analysis, are also based on the Feature Dictionary representations used by the manual analysis. The OMR algorithms will become part of the ORDBMS by implementing them as a set of user-defined function for processing the score images supporting the manual analysis. The integration of image analysis functions into ORDBMS and content-based retrieval systems, is discussed in [2,4].

To provide comprehensive methods for data access and retrieval the implementation of different user scenarios illustrated in Fig. 2 is required. One of the most frequently used data access methods is searching. We provide the opportunity to search the archive for words and phrases in bibliographic metadata and source description data using the full-text extension. A second data access possibility is a convenient browsing through metadata, score images, or the Feature Dictionary. The last one and most complex search scenario is a very important access method for musicologists, where a scribe identification can be performed using the Feature Dictionary. Two approaches are implemented: a manual analysis and an automatic analysis and identification. The manual identification is based on browsing through the Feature Dictionary to find similar features to the unknown scribe. Known scribes with similar characteristics are retrieved from the database after comparing the handwriting characteristics of the unknown scribe with those of the scribes classes stored in the database. The scribe identification by automatic analysis is based on the OMR algorithms mentioned above. A scanned page of a score is processed to extract the corresponding handwriting characteristics automatically and then the scribes with the highest score of similarity on their handwriting characteristics from the database

are presented as candidates for the identification. If the degree of similarity in both cases is not satisfactory a procedure for adding a new scribe class will be carried out.

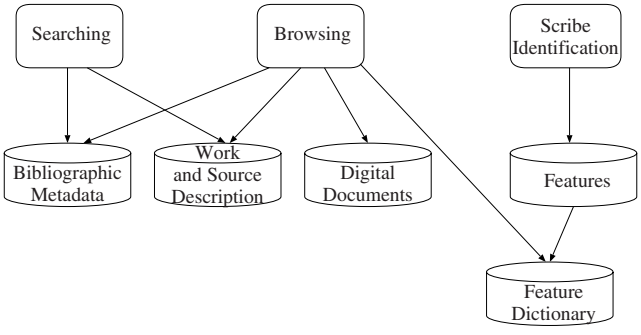

Fig. 2. User Scenarios

3 Conclusions

The presented digital archive of historical music scores enables data storage, analysis, retrieval, access and presentation of music material. Moreover the intelligent system extension for scribe identification, supporting the data analysis and mining is an essential part of the implementation, which sets new requirements to digital archives and libraries. Considering the need to integrate other regionally and historically varying music scores a reliability and validity evaluation and possibly adaptation of the results from the handwriting characteristics extraction and the methods for their analysis will be carried out.

References

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