Interactive Multimedia Music Technologies

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concepts to model the visual aspects of a music score, and audio information or annotations related to the music piece, allowing integration with other audiovisual elements by multimedia references. The Symbolic Music Representation standard overcomes the limitations of a widely accepted format like MIDI, which is in line with its main purpose to model music events, whereas it reveals important limitations in producing audio and visual representations with satisfactory results.

Chapter III

The evolution of information technology has changed the use of music representation and notation in software applications, transforming and extending them from a simple visual coding model for music scores into a tool for modelling music for computer programs and electronic devices in general (e.g., keyboards), to support the exploitation of the multimedia characteristics lying behind music notation and representation. The MPEG symbolic music representation (MPEG-SMR) is a new emerging standard for modelling music notation within the MPEG multimedia framework. MPEG-SMR provides an XML-based language to model most of the music notation in terms of the visual and audio aspects, as well as music score annotations. MPEG-SMR also provides a language to define the music score formatting rules, supporting personalisation for the score visual presentation, custom symbols, and control visual rendering of the common notation symbols.

Chapter IV

This chapter presents the applications and practices in the domain of music imaging for musical scores (music sheets and music manuscripts), which include music sheet digitisation, optical music recognition (OMR), and optical music restoration.

With a general background of optical music recognition (OMR), the chapter discusses typical obstacles in this domain, and reports currently available commercial OMR software. It reports hardware and software related to music imaging, discusses the SharpEye optical music recognition system, and provides an evaluation of a number of OMR systems.

Besides the main focus on the transformation from images of music scores to symbolic format, this chapter also discusses optical music image restoration and the application of music imaging techniques for graphical preservation and potential applications for cross-media integration.

Chapter V

Optical music recognition is a key problem for coding western music sheets in the digital world. This problem has been addressed in several manners, obtaining suitable results only when simple music con-

structs are processed. To this end, several different strategies have been followed to pass from the simple music sheet image to a complete and consistent representation of music notation symbols (symbolic music notation or representation). Typically, image processing, pattern recognition and symbolic reconstruction are the technologies that have to be considered and applied in several manners the architecture of the so-called OMR (optical music recognition) systems. In this chapter, the O³MR (object oriented optical music recognition) system is presented. It allows producing, from the image of a music sheet, the symbolic representation and save it in XML format (WEDELMUSIC XML and MUSICXML). The algorithms used in this process are those of the image processing, image segmentation, neural network pattern recognition, and symbolic reconstruction and reasoning. Most of the solutions can be applied in other fields of image understanding. The development of the O³MR solution with all its algorithms has been partially supported by the European Commission, in the IMUTUS Research and Development project, while the related music notation editor has been partially funded by the research and development WEDELMUSIC project of the European Commission. The chapter also includes a methodology for the assessment of other OMR systems. The set of metrics proposed has been used to assess the quality of results produce by the O³MR with respect to the best OMR on market.

Chapter VI

XML-based languages for music have constraints not applicable to typical XML applications, such as for standard text documents or data sets. Music contains numerous simultaneous events across several dimensions, including time. The document model for a piece of music would thus look very different from serialised text documents. Most existing XML-based music markup languages mark music typography, following the print traditions of music scores. A general music markup language should include much more than mere print. Some of the challenges designing an XML-based markup language for music are considered. An SVG-based music symbol design grid is proposed to meet the challenge of music typology. An XML-based Music Symbol Language is used to design symbols on this grid. Resulting symbols are positioned in 3-D music space, which is introduced to address the challenge of topography.

Chapter VII

Design goals determine the particular structure of a markup language, while the philosophy of what markup languages are about determine the framework within which its structure is developed. Most existing markup languages for music reflect low-level design strategies, compared to design that adheres to the high-level philosophy of markup languages. An approach to an XML-based music markup language from the perspective of SGML would differ from an approach from a markup language such as HTML. An ideal structure for a general markup language for music is proposed that follows a purist approach and that results in a different kind of XML-based music markup language than most present music markup languages offer.

Our work bridges two interesting topics: the research in the area of Web-based applications and the area of learning technologies. We give an overall picture of the current development in Web-based music intelligent tutoring system (WMITS). The term WMITS is coined by us to describe the two main areas in our focus. In this chapter, we address the following issues: (i) the pedagogical aspect of teaching and learning music, (ii) the background of music intelligent tutoring system, and (iii) our WMITS system for teaching music theories. A Web-based environment offers strengths in terms of accessibility and self-paced learning. However, the environment has a great drawback in terms of interactivities between the users and the system. Our design addresses this issue by developing a specialised client tool. The client tool provides an interactive environment for score editing, which is crucial for learning music theories. The system incorporates three major inference techniques (i.e., deductive, inductive, and Bayesian inference) in dealing with music theories and uncertain knowledge such as students' understanding.

This chapter discusses technologies and standards related to digital rights management (DRM). Firstly, it presents DRM systems that are multimedia information management systems that take into account digital rights and protection. These systems enable the controlled distribution and use of multimedia content through the digital value chain. Then, this chapter presents current initiatives, standard and proprietary, that specify a DRM system. It focuses in the MPEG-21 standard initiative, mainly in the parts of this standard that normatively specify the different pieces and formats needed by a complete DRM system. Finally, this chapter presents one of the key components of DRM systems, rights expression languages (RELs), that have been defined to express content usage rules.

This chapter explains the fundamental principles of audiovisual content protection. It explains the basic knowledge that is needed to understand the fundamentals of digital rights management (DRM) systems and their problems. Starting with a general introduction about copyright and content protection, available protection technologies are described and analyzed. The basic concepts of DRM solutions are explained and problems discussed. Potentials and practical limitations are analysed based on the digital music industry value chain. An outlook is given on solutions that are under development and that stronger consider the needs of the customers. In the conclusion, future solutions are discussed.