Chapter IX
Music Information Retrieval in P2P Networks

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ABSTRACT

In this chapter we present the most significant trends in recent research in the field of content-based music information retrieval in peer-to-peer networks. Despite the diminished attention the area has received in general terms, the relatively close area of metadata MIR in P2P is by far new. As metadata prove to be inefficient for the purposes of MIR as well as the peculiarities of music in comparison to text and image data, developing dedicated solutions for CBMIR in P2P networks becomes a necessity while the challenges faced therein, unique. Depending on the type of P2P network, a number of prominent research works are presented and compared in this chapter.

INTRODUCTION

The World Wide Web (WWW) is being used for commercial, entertainment, and educational purposes and has become the primary means for information dissemination. One popular type of data that is being disseminated over WWW is digitised music. Recently, the new opportunities that emerge from this activity have been recognized and led to the development of systems like iTune (www.apple.com/itunes), iMusic (www.imusic.com), and Napster (www.napster.com). Although abundantly used, even nowadays, traditional metadata (title, composer, performer, genre, date, etc.) of a music object give rather minimal information regarding the actual content of the music object itself. On the other hand, research efforts in the field of music information retrieval (MIR) have developed efficient methods for searching music data collections by content. For instance, queries based on humming (using a microphone) or on a small piece of musical file, are far more natural an approach to MIR. This type of queries lies within the content-based MIR (CBMIR). In CBMIR, an
actual music piece is required in order to compare its content with the content of the music pieces already available in a database.

As with regard to the infrastructure for exchanging music data, peer-to-peer networks over the WWW have gained significant popularity. A peer-to-peer (P2P) network is a distributed system in which peers employ resources that are distributed in the network of peers in order to perform a function in a decentralized manner. Nodes in P2P networks normally hold equivalent roles, thus, also called peers. Within the advantageous qualities of the P2P networks lie the increased size of the overall database offered by a P2P network, its fault tolerance support to peer failure by other peers and the workload distribution over a network of available CPUs, since CBMIR is computationally highly intensive, the absence of the requirement of special administration or financial arrangements and their self-organization capability and adaptability. Additionally, P2P networks offer the ability to harness the collaborative efforts of users to provide various semantic tags aiming at musical content description. Nonetheless, the very advantages of the P2P network are the same parameters that make P2P information retrieval much more complex than in the traditional server-client model. That is, the lack of a central repository for the documents to be retrieved, the large number of documents available and the dynamic character of the network, introduce an increased degree of difficulty in the retrieval process. Accordingly, as collections become larger, CBMIR in P2P networks presents new and challenging requirements the highlights of which are:

- Richer set of search semantics that can support efficient CBMIR
- Appropriate P2P models that ensure scalability
- Distribution of the workload over a network of available CPUs, as CBMIR is computationally intensive.

Though, despite the previously mentioned advantages of P2P networks, the trend of musical data dissemination over P2P networks became obscure by the illegal exchange of copyrighted material. One of the key advantages of P2P networks, as previously discussed, is the lack of necessity for an administration, which acted as a loophole. Accordingly, numerous approaches (Chu, Su, Prabhu, Gadh, Kurup, Sridhar et al., 2006; Kalker, Epema, Hartel, Lagendijk, & Steen, 2004; Praveen, Sridhar, Sridhar, & Gadh, 2005) for the protection and reproduction of intellectual property have been proposed, while the field is still developing (Dhamija & Wallenberg, 2003; Dubosson-Torbay, Pigneur, & Usunier, 2004; Sastry, 2005; Schyndel, 2005), both in terms of technology as well as ethics. CBMIR applications in P2P networks can, and must, adopt any such developments.

The field of music information retrieval has received increased attention during the last decade. Numerous surveys examine the state of the art developments in the area (Byrd & Crawford, 2002; Karydis, Nanopoulos, & Manolopoulos, 2006; Orio, 2006; Typke, Wiering, & Veltkamp, 2005) while a litany of works spawns rapidly in all directions of MIR.

Although outside the scope of this chapter, work in multimedia (other than music) information retrieval in P2P networks (Lew, Sebe, Djeraba, & Jain, 2006) shows a wealth of research issues that still remain open. Moreover, multimedia IR in P2P faces similar problems (such as indexing high-dimensionality data) appearing to MIR in P2P, though the difference of the nature of the data, such as interfaces, data representation as well as data volume issues, requires, in many cases, a completely differentiated approach. Additionally, multimedia IR research is naturally complemented by streaming in P2P networks research as many of the retrieved multimedia documents are videos. Therein lie more open research issues (Liu, Kundur, Merabti, & Yu, 2006).