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Digital Music Piece Identification using Local Maxima

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Abstract. BitTorrent is one of the most common P2P protocols for distributing large files over the Internet. Internet users can easily share their movie and music files using BitTorrent. The file is shared by dividing into pieces and BitTorrent seed file has the hash values of each pieces for identifying each piece. It means the piece is not identified without seed file. In this paper we proposed an improved identification method for music pieces using local maxima and general chromatic algorithm without seed file. The method improved the identification ratio up to 31% more than that using general chromatic algorithm.

Keywords: BitTorrent; music piece; identification; local maxima, chroma feature.

1 Introduction

Mp3 distribution sites, including mp3.com and Napster, were closed or bought by other companies as a result of lawsuits, because peer-to–peer (P2P) file-sharing technology was blamed for enabling copyright infringement [1][2]. After the end of year 2000, BitTorrent protocol was spread as a method to share contents.

BitTorrent is a P2P file-sharing technology developed by Bram Cohen in 2001[3]. BitTorrent provides file-sharing capability at high speed using 1-to-*n* peer connections, unlike previous P2P technologies. BitTorrent is a highly innovative technology for distribution of digital content, and copyright owners have blamed it for enabling infringement, because it allows the sharing of digital content with unspecified individuals [4].

To prevent the illegal distribution of copyright-protected materials through the internet, we'd better extract the feature of the content and identify whether it is a copyright-protected content. First of all, we have to analyze the data downloaded by the BitTorrent client program whether it is enough to extract the correct feature.

In this paper, we proposed a method of audio recognition on a few pieces of music files. The audio identification algorithm consists of beat tracking and chroma features [5]~[8]. A beat tracker is used to generate a beat-synchronous representation with one feature vector per beat and the representation of each beat is a normalized chroma vector which sums up spectral energy into 12 bins. To identify the downloaded piece,

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two beat tracks obtained from original audio file and downloaded piece are matched by using cross-correlation.

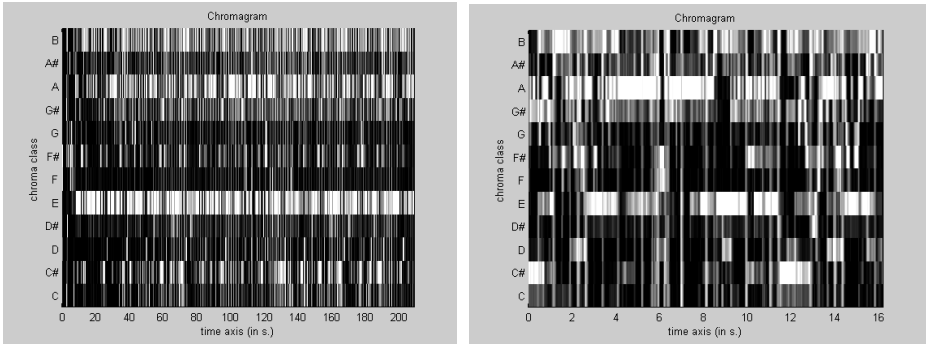
This paper is organized as follows. In Section II, we present the audio identification algorithm. In Section III, we discuss the evaluation of simulation results. In Section IV, we conclude the superiority of the proposed algorithm.

2 Music Identification

In general, a music file has its own unique features such as beat, melody, harmony, chroma and etc. For identifying a music, the unique features should be extracted from the music and the similarity should be checked by distance measure or cross-correlation.

2.1 Chroma Features

Chroma features consist of a 12 element vector with each dimension representing the intensity which is associated with a particular semitone. To identify strong tonal components in spectrum and get a higher resolution estimate of underlying frequency, use phase derivative within each FFT bin. Each recording is represented by a matrix of 12 chroma dimensions. Figure 1 shows chromagrams of an audio recording and one piece of it. Finally, the identification is implemented by cross-correlating the two feature matrices of piece and original.



(a) An audio recording (b) One piece

Fig. 1. Chromagram of an audio recording and one piece

2.2 Improved Identification Algorithm

Existing identification algorithm experimented with chopping one piece up into multiple fragments and looking for the best cross-correlation of each fragment in the

test piece, but in addition to being very slow it was difficult to choose the best length of fragment size.

The improved identification algorithm extracts twelve element chroma features with high speed 2D cross correlation using 2D FFT. Figure 2 shows a flowchart of improved identification algorithm.

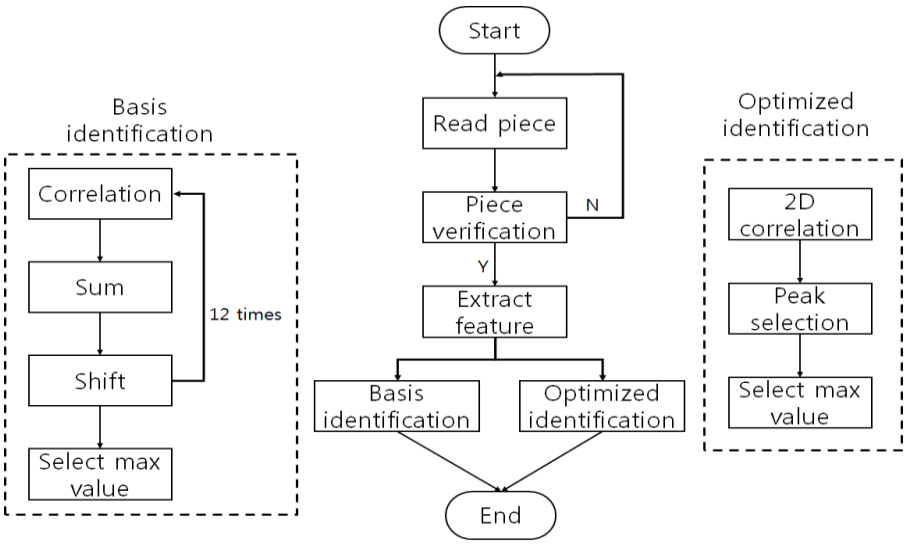


Fig. 2. Flowchart of existing and optimizing identification method

When we select the maximum value of the correlation peaks, the maximum peak sometimes does not mean it is matched with the music feature because there are many peaks which are not related the exact feature. Therefore, the proposed algorithm specifies the range occurring the correlation peak and we can choose exact local maxima for enhancing the identification performance.

3 Evaluation

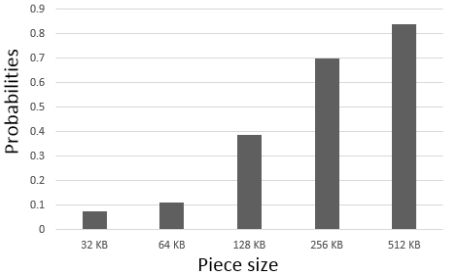
The existing method is evaluated with 30 pop song samples and sample file size is between 2 MB and 5 MB. Suppose the piece size is 256 KB, the playback time of the piece will be 16 seconds with the bitrate of 128 Kbps. But in fact, the bitrate of audio file on BitTorrent is unpredictable, which means it depends on how the MP3 file owner compress the audio, thus, the bitrates of samples were not fixed. Figure 3(a) shows the probabilities of successfully identifying pieces of 30 samples against different piece sizes. In this test, each sample was identified with only one piece of it. The results show if the piece size is less than 256 KB, it is difficult to identify the piece correctly. It also means if the playback time of an audio is less than or equal to 8 seconds, the audio will be unrecognizable. Figure 3(b)~(d) show the probabilities of

successful identification against different number of pieces with fixed piece sizes. In the case of piece size being equal to 64 KB and 128 KB, all the samples are evaluated 15 times, whereas 8 times for 256 KB, and each time the number of pieces is increased by 1. Obviously, the results show the more pieces we have, the better identification results we can obtain.

Table 1 shows compared results between conventional algorithms and the proposed algorithm when 400 music samples were tested. The proposed algorithm improves identification rate by 31% when a piece size is 256KB and 15.25% when a piece size is 512KB. Also, the algorithm enhances identification speed.

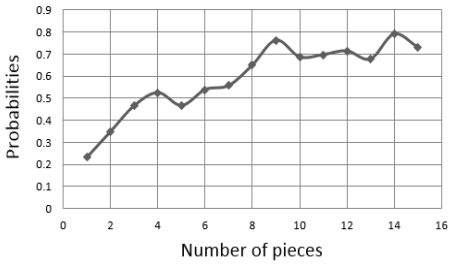
Table 1. Comparison with other identification algorithms

Algorithm	Piece size	Identification rate	Algorithm	Piece size	Identification rate
Conventional	256KB	52%	2D-Cross Correlation	256KB	77%
	512KB	69.75%		512KB	87.5%
w/o rotation	256KB	57.5%	Local Maxima	256KB	83%
	512KB	73%		512KB	85%

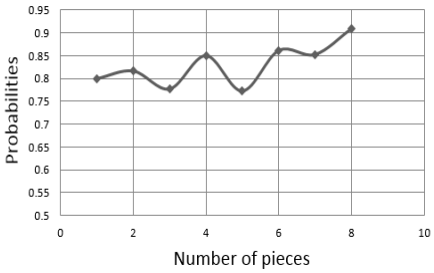


(a) Probabilities by piece size

(b) Piece size of 64KB



(c) Piece size of 128 KB



(d) Piece size of 256 KB

Fig. 3. Probabilities of different number of pieces with fixed piece sizes

4 Conclusions

In this paper, we proposed an improved music identification algorithm. The conventional algorithms dealt with the features from all frames of music. However, the piece which is received from BitTorrent peer has a small part of the all frames. This has not enough information to identify what the music is. The proposed algorithm uses a local maxima search and it improved the identification rate up to 31% more than that of the conventional algorithm.

In the future work, we are going to improve the speed of classification because there are over 100 million songs in the world.

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