

Crystal: A Content-based Music Retrieval System

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Content-based music retrieval is attractive and has potential application in music copyright searches. Image the convenience of allowing users to retrieve a piece of music based on the music contents, especially based on an incomplete, imperfect recall of a fragment of the music. However, there are some query mismatch problems specific to music retrieval [1-2]. First, since melodies are recognizable regardless of what key they are sung in, the system must allow users to input notes in any key [3]. Second, users may submit, either by singing or by keyboard input, an imperfect music fragment [4]. Some approximate match functions for occasional pitch error and random note deletion and insertion are desirable. In addition, music data are not easily perceived visually and expressed literally. Any facilities for efficient input, browsing, and selection would help in query formulation and result inspection.

A content-based music retrieval system expanded from a previously developed retrieval system, called Crystal [5], to tackle these problems will be demonstrated. A pitch profile encoding is used for allowing queries in any key and an *n*-note indexing method is adopted for approximate matching in sub-linear time. The most distinct feature of this system is the key melody extraction module that extracts representative and memorable melodies from the music collection for query suggestion and effective retrieval [6]. Users can search the key melodies with any pieces of familiar fragments occur to them. Relevant key melodies can be matched at a lower score and then be used to pull out their corresponding tunes from the music collection. The overall effect is that the response time and search failure are both reduced even with more discrepancy between queries and the music data.

The system is developed on the Web and provides flexible user interface for query formulation and result browsing. Several input methods can be used to make query in this system. The system can randomly generate a set of key melodies for users' browsing, listening, and selection such that making queries without any musical data input is possible. Users can also choose to input a short sequence of notes with simplified notation to quickly focus on the pieces of music they

are interesting. Another option is to make a query by uploading a file created locally by singing or humming with some melody transcription software available in the Internet. In any way, the system responses a playback button, a set of automatically expanded query candidates, and a result set based on the current query. The playback button allows users to hear what they enter, the query candidates are ready to be submitted in case of search failure for the current query, and each of the key melodies or music pieces present in the result set can be played and selected for further searching.

Besides, the system allow queries by composers, titles, instruments, file names, and other text data with the same indexing scheme, i.e., *n*-note (*n*-word) indexing. All these text information are collected from MIDI files. This makes the system an integrated one that can be searched by contents and by surrogates as well.

To allow comparisons among different retrieval approaches, this system also provides melodies matching by dynamic programming that tolerates note deletion and insertion and an exact matching method that measures the Hamming distances between queries and the melody collection.

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