PROMS: A Web-based Tool for Searching in Polyphonic Music*

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Abstract

One major task of a digital music library (DML) is to provide techniques to locate a queried musical pattern in all pieces of music in the database containing that pattern. For a survey of several computational tasks related to this kind of data retrieval we refer to Crawford et al. [3]. Existing DMLs like MELDEX [1], Themefinder [4], and the Sonoda-Muraoka-System [7] work with melody databases relying on score-like information. Retrieval and matching are performed in a fault-tolerant way by string-based methods which mainly take into account pitch information. Generally, rhythm plays only a subordinate role. The music dictionary of Barlow and Morgenstern [2] shows that music retrieval based on pitch information only leads to results with typically too many false matches. (An example of such absurd matches is given in Selfridge-Field [6], p. 27.) We are convinced that *both* pitch and rhythm are crucial for recognizing melodies. In the more general context of polyphonic music, one is even forced to consider pitch and rhythm information.

PROMS, a web-based computer-music service under development at the University of Bonn, Germany, is part of the MiDiLiB project [5]. The aim of PROMS is to design and to implement PROcedures for Music Search. Our discussion will take place in a rather general setting: we assume that our database contains several kinds of music such as polyphonic and homophonic music as well as melodies. We also use score-like information. A query to the database is a fragment of a piece of music. This could be a melody or a certain figure of an accompaniment. The task is now to locate efficiently all occurences of this fragment in all pieces of music in the database.

We have designed and implemented a web-based computer-music service that enables seaching in polyphonic music. In contrast to the above mentioned systems, PROMS is not string-based but set-oriented. The basic objects within the PROMS system are single notes, specified by its onset time t, its pitch p, and its duration d. A piece of music is then a finite set M of notes. Our database consists of a sequence of N pieces of music in the MIDI format: $D_1, \ldots, D_N$. Similarly, a query is itself a finite set Q of notes. Thus there is no principal difference between a piece D_i of music in the database and a query Q. However, typically, D_i is much larger than Q. An occurrence is a pair

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(i, v) such that the v-shifted version of Q is a subset of D_i: $Q + v \subseteq D_i$. Combining methods from Computer Algebra with well-established techniques from Full-Text-Retrieval, we obtain a time and space efficient polyphonic music information retrieval system. This is best illustrated by some performance data (on a Pentium II, 333 MHz, 256 MB RAM, Windows NT 4.0): The PROMS database consists of 327 MB of MIDI data, our index consumes only 22 MB, the time to construct our index is about 40 seconds. Finally, the average response time is about 80 milliseconds.

Here are some highlights of our system: PROMS considers pitch and rhythm simultaneously. It supports polyphonic queries. The processing time depends essentially on the number of notes in the query. Queries might contain "gaps". It supports user- and problem-adapted indexing on-the-fly. It allows fuzzy search and transposition-invariant search. With little additional effort, it allows to compute all occurences of a query with at most k mismatches.

References

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