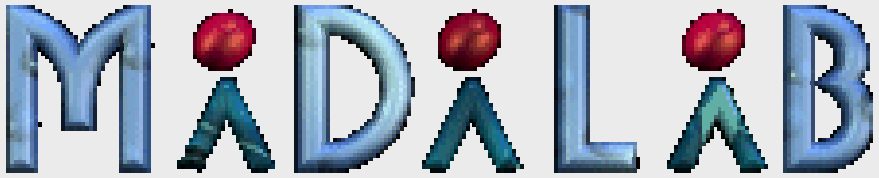


Content-based Indexing, Retrieval, and Compression of Musical Data

M. Clausen, R. Engelbrecht, D. Meyer

University of Bonn

Part 1: Indexing and Retrieval

- Design and implementation of a web-based digital music library
- Content-based indexing and retrieval of music in the MIDI format
- Tools for analysis, editing, and visualization

Part 2:
Cascaded Lossy Audio Coding

- Problem: audible distortions
- Prevention: psychoacoustic steganographic (data embedding) technique (→ patents)
- 1999 GI Dissertation Award: Frank Kurth

Recent Publications (Part 2)

- Kurth, F: Perceptually transparent attachment of content-based data to audio-visual documents, IEEE ICME 2000, New York
- Kurth, F. & Hassenrik, V.: A dynamic embedding codec for multiple generations compression, 109th AES Convention, L. A., 2000
- Packham, N. & Kurth, F.: Transport of content-based information in digital audio data, 109th AES Convention, L. A., 2000

Today´s Topic:

Content-based Indexing and Retrieval of Polyphonic Music in the MIDI Format

Related Projects

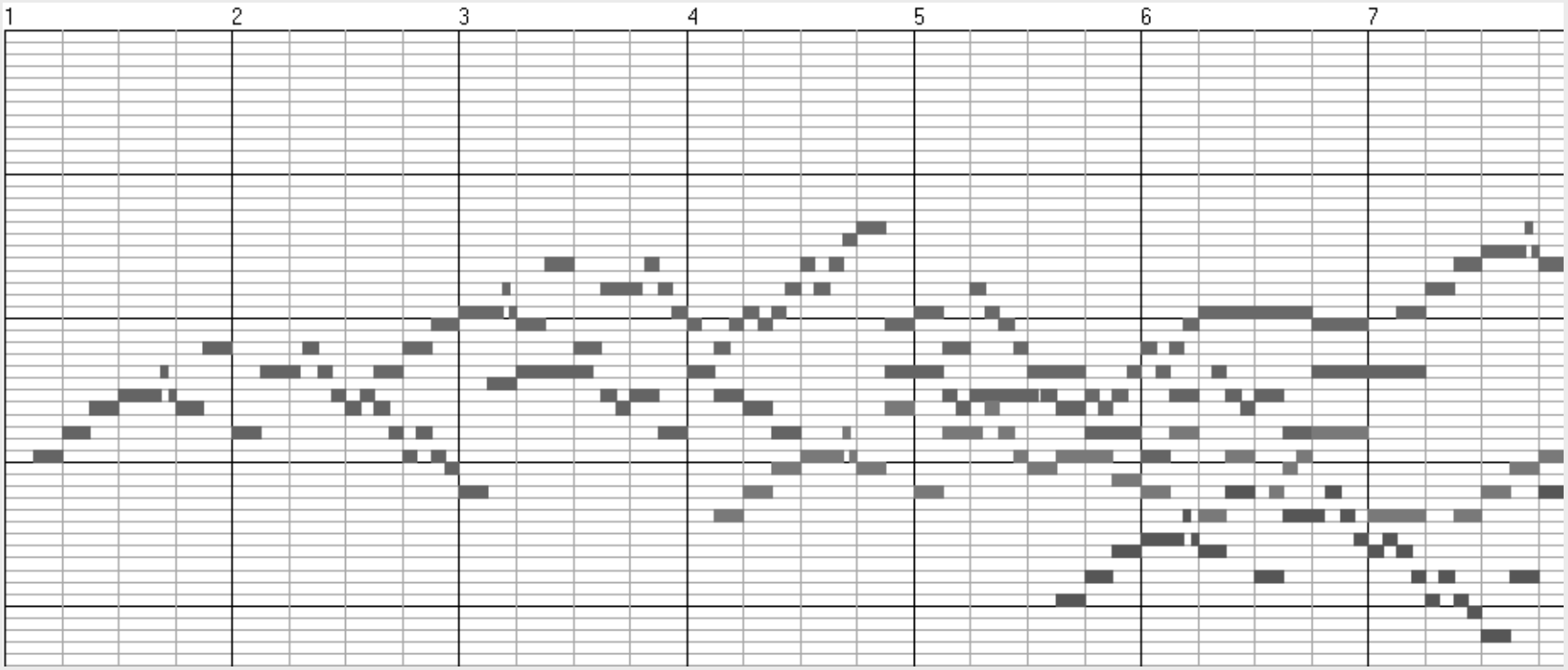
- MELDEX (Waikato, NZ)
  - Database of folk songs
- Themefinder (Stanford, USA)
  - Database of classical musical themes
- Sonoda-Muraoka-System (Waseda, JP)
  - Database of melodies

These systems allow fault-tolerant search in **monophonic** pieces of music

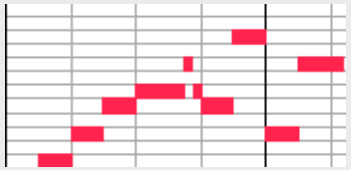
Problem Specification

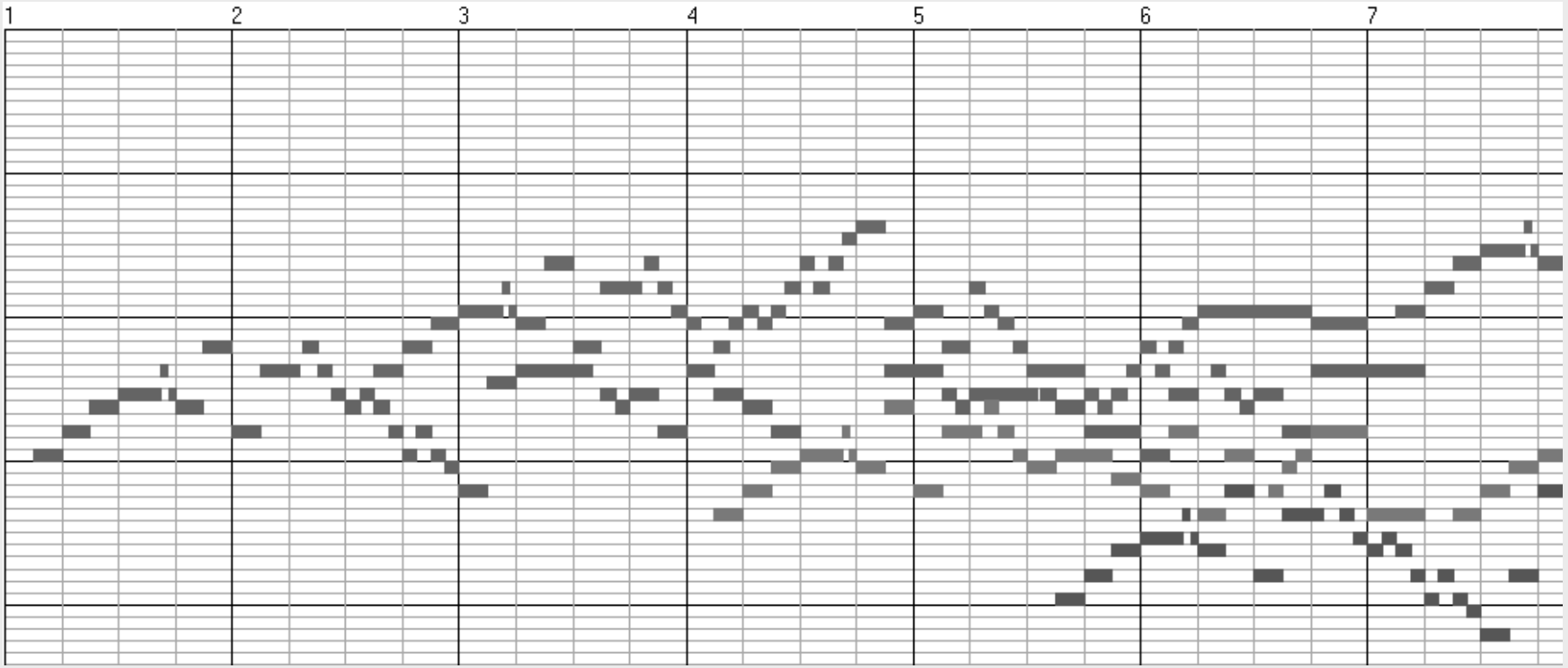
- Database: Polyphonic MIDI files D_1, ..., D_N
- Input: A polyphonic musical pattern Q
- Output: All occurences of Q in D_1, ..., D_N

Polyphonic Music

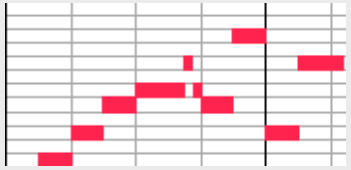


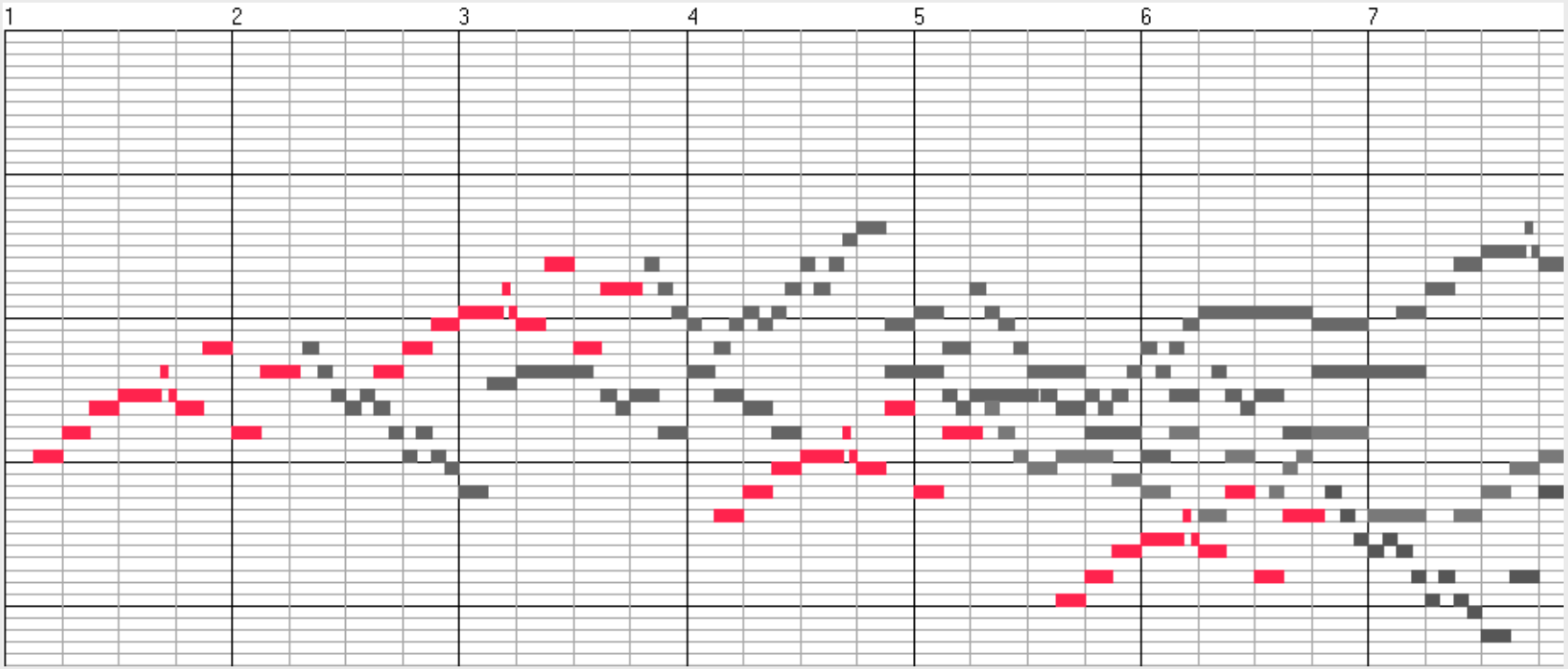
Example of a Query





Example of Matches



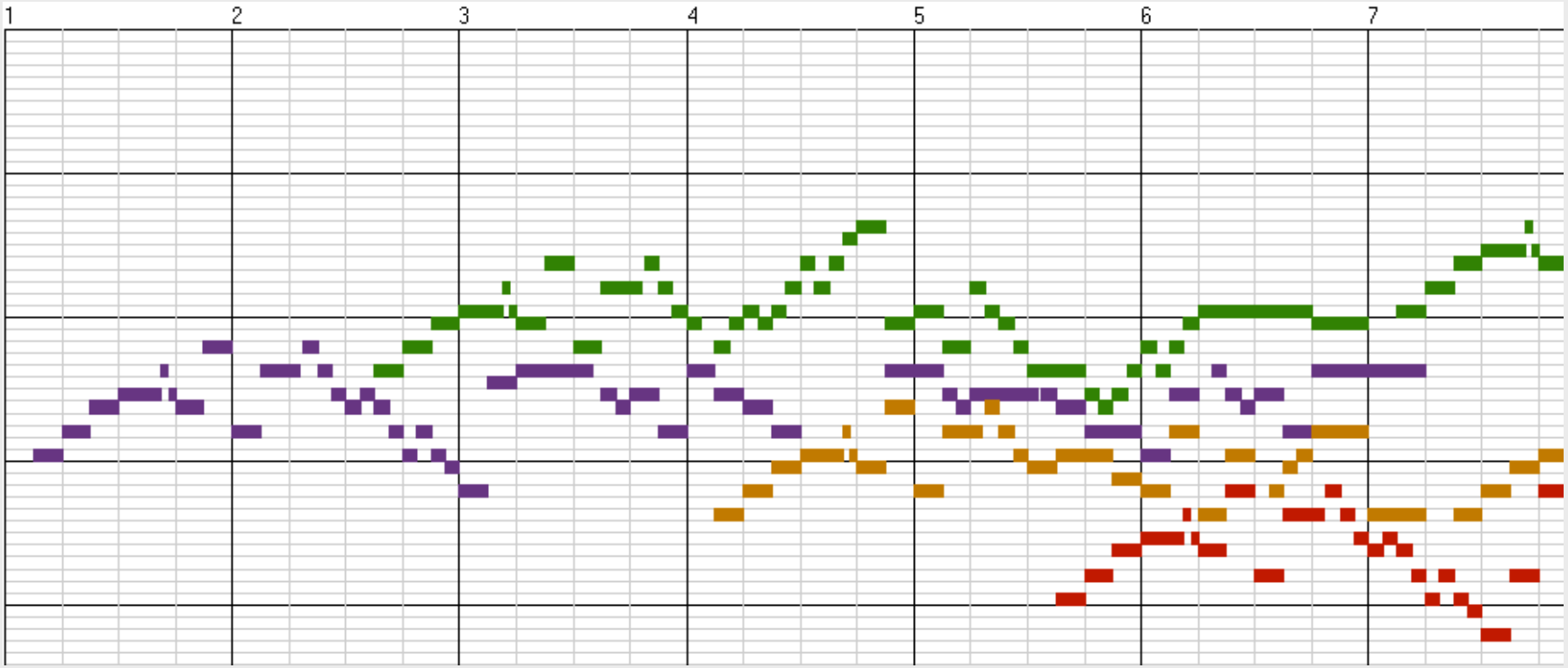


Conventional Strategy

- Polyphonic music as a collection of melodies
- Extraction of melodic lines, themes, motives, etc.
- String-based representation of melodies
- String-based search methods

This strategy has proved unsuccessful.

Polyphonic Music



The Atomic Point of View: **PROMS**

- Not string- but set-oriented
- Basic objects: single notes (t,p,d)
- Piece of music: a finite set M of notes
- Database: a sequence D_1, ..., D_N of pieces of music
- Query: a finite set Q of notes
- Occurence: (i,v) s.t. $Q + v \subseteq D_i$

PROMS in a nutshell:

Computer Algebra & Full-Text-Retrieval

Time and space efficient Polyphonic Music Information Retrieval

PROMS vs. Sonoda

	PROMS	Sonoda-System
Index Type	polyphonic	monophonic
MIDI data (MB)	327	100
Number of notes (million)	33	10
Index size (MB)	22	531
Index construction time (min)	0.66	1376
Avg. response time (sec)	0.08	0.78

The Sonoda-Muraoka-System (Waseda University, Tokyo) was presented at the ICMC 2000, August 2000, Berlin.

PROMS: Highlights

- Pitch **and** rhythm
- Polyphonic queries supported
- Processing time depends essentially on $|Q|$
- Queries may contain ´gaps´
- User- and problem-adapted indexing on-the-fly
- Fuzzy Queries and Fuzzy Search
- *k* mismatches with little additional effort
- Ranking

Publication (Part 1)

- M. Clausen, R. Engelbrecht, D. Meyer, J. Schmitz:

  PROMS: a web-based tool for searching in polyphonic music, to appear in Proc. of Int. Symposium on Music Information Retrieval, Plymouth, Mass., USA, Oct. 2000

Future Work

- Advanced ranking methods
- Similarity
- Searching in audio data

Beyond PROMS

- PROMS search method can be generalized substantially
- This is subject of patent applications