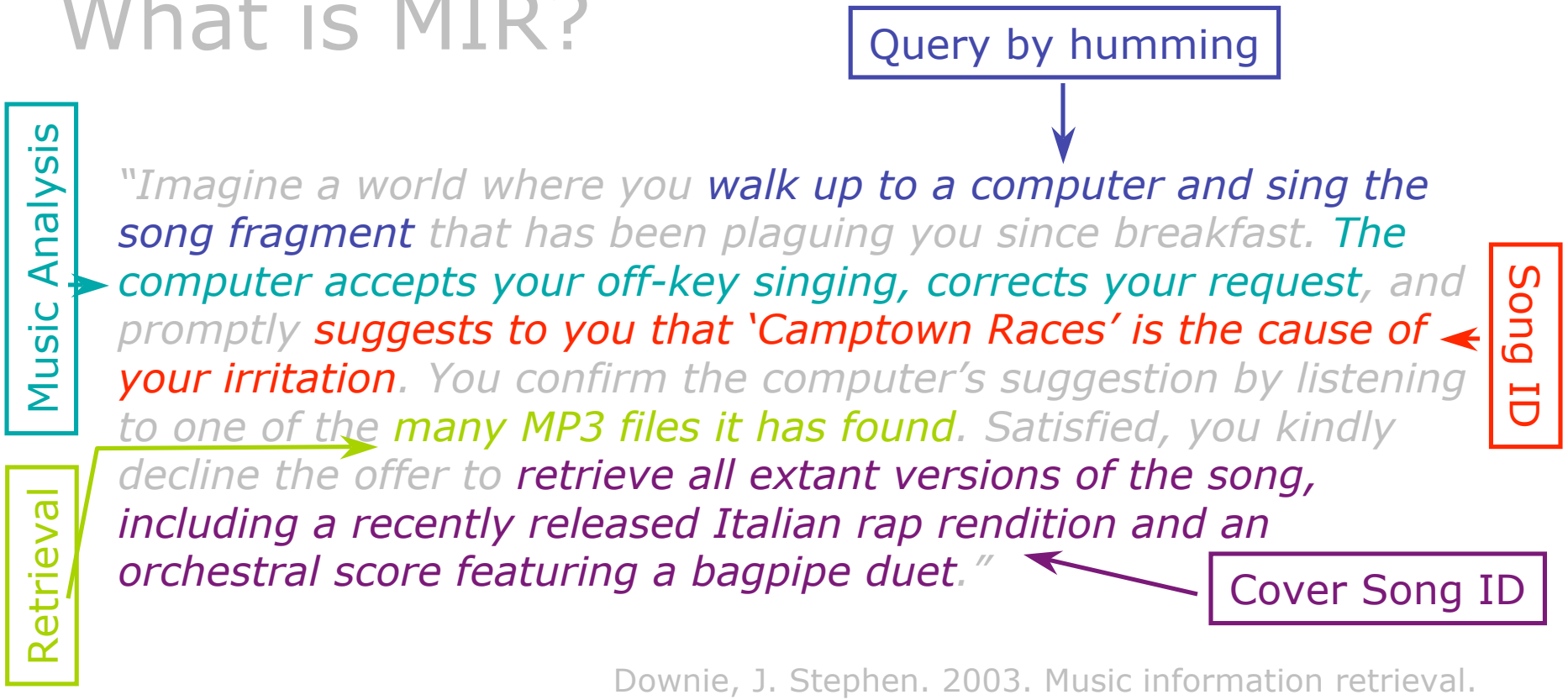
E85.2623
Music Information Retrieval

Juan P Bello

What is MIR?



"Imagine a world where you walk up to a computer and sing the song fragment that has been plaguing you since breakfast. The computer accepts your off-key singing, corrects your request, and promptly suggests to you that 'Camptown Races' is the cause of your irritation. You confirm the computer's suggestion by listening to one of the many MP3 files it has found. Satisfied, you kindly decline the offer to retrieve all extant versions of the song, including a recently released Italian rap rendition and an orchestral score featuring a bagpipe duet."

Downie, J. Stephen. 2003. Music information retrieval. *Annual Review of Information Science and Technology 37*: 295-340. Available from http://music-ir.org/downie_mir_arist37.pdf

(a few possible) Applications

- Use a recorded song (from the environment) as a query
- Automatically create a playlist from your collection for a studying or workout session
- Match the beat of consecutive songs for DJ-ing purposes
- Automatically go to the guitar solo of a piece
- Find other music in the style of this composer, or variations of a given piece
- Have a recorded orchestra that follows you when you practice the trumpet
- Get a system to recommend you new music based on your current tastes
- Have a personalized radio station

Why now?

- Accelerated growth of Online and Mobile technologies
- Continuous growth of material: 10K albums released and 100K pieces copyrighted per year
- Ubiquitous MP3s (and related compression formats), expediting music distribution
- Music is the most popular request in search engines
- Great availability of music-related data: audio, score, metadata, related media, etc.
- Emerging (online) communities of music lovers
- MIR, as a research field, is the result of the need for dealing with this increased availability of digital music contents
- Potential to make even more music available from existing back catalogues (e.g. from libraries and music archives) + Many interesting new applications of its core technologies

The business case

- IFPI Digital Music Report 2007: http://www.ifpi.org/content/section_resources/digital-music-report.html
- Digital sales globally: US$2 billion in 2006, from US$1.1b in 2005, from US$380M in 2004 (~5-fold in 2 years)
- Revenues from digital music: 10% of total revenues (6% in 2005, ~0% in 2003): expected to be 25% by 2010.
- Single track downloads estimated up 89% at 795M.
- 500 legal download sites from (335 in 2005) 50 in 2003. Song catalogue has duplicated (4M tracks in 2006, 2M in 2005)
- More lawsuits against sites distributing music illegally (a more protective industry)

The business case

- 120M portable players sold (up 43% from ~60M in 2005)
- Digital sales are split 50:50 between online and mobile
- Master ringtones account for 87% of mobile sales
- In Japan, mobile sales are around 90% of total digital music sales
- Every day there are more business models based around this expansion (social networks, subscription-based, etc)

Commercial services

- +500 Music distribution services
- iTunes features: 3M songs, >3K videos and TV shows, 35k podcasts, 16K audiobooks, 1b+ songs sold to date, 15M+ videos purchased
- Personalized radio stations and recommendation systems (e.g. www.last.fm , http://www.pandora.com/ , www.gracenote.com)
- Query-by-example / Song-ID systems (Shazam: www.shazam.com , AT&T, www.411song.com (#SONG), Philips and Fraunhofer Institute)
- Music recommendation and browsing (http://www.musintelligence.com/)
- Music analysis for hit prediction (http://www.platinumblueinc.com/)
- Music Visualization (http://www.liveplasma.com/)
- Automatic DJ-in, etc, etc (http://echonest.com/)

MIR research community

- Centers around the International Conference on Music Information retrieval (ISMIR)
- Begun in 2000 as a symposium (hence the S) sponsored by the NSF as a complement to the OMRAS project.
- It span from preliminary workshops in MIR at SIGIR 99 and Digital resources for the Humanities 1999.
- 2000: 10 presentations, ~40 participants. 2005: 115 presentations, 220+ participants.
- Last Conference: Victoria, Canada http://ismir2006.ismir.net/ and Next Conference: Vienna, Austria http://ismir2007.ismir.net/
- A mailing list with 800+ subscribers and an ISMIR domain. A 10-strong Steering Committee.
- Multidisciplinary: Information science, Computer Science, Music/Musicology, Electronic engineering, Psychology, Law, Industry, etc.

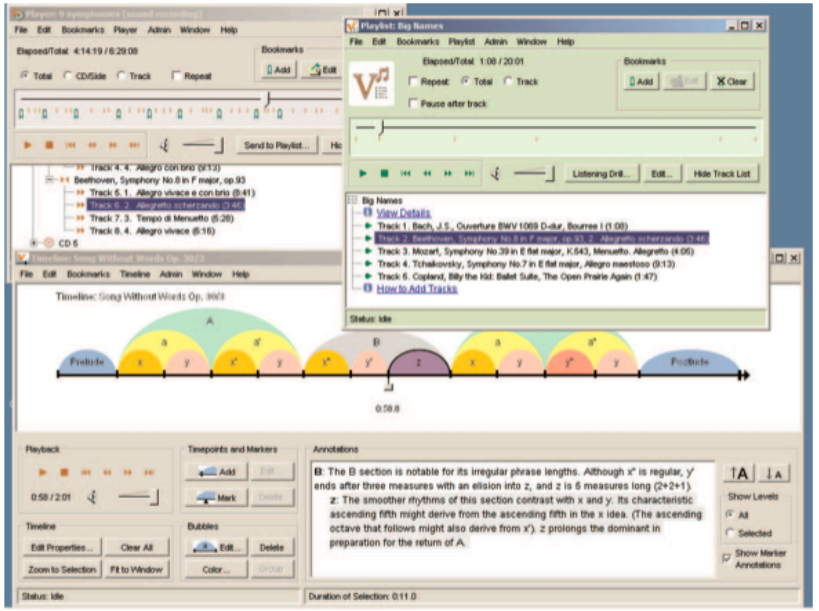
MIR community in a few links

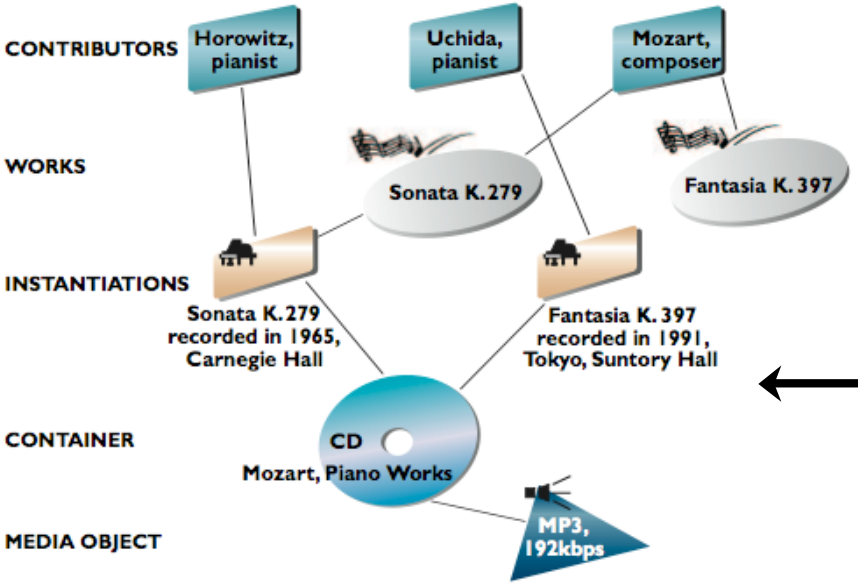
- ISMIR home: http://www.ismir.net/
- Music-IR home: http://www.music-ir.org/
- MIR mailing list: http://ismir2002.ismir.net/mailing-list.html
- All ISMIR papers: http://www.ismir.net/all-papers.html
- Shared Bibliography: http://www.music-ir.org/research_home.html
- MIR-related PhD theses: http://www.pampalk.at/mir-phds/
- Listing of available test collections: http://php.indiana.edu/~donbyrd/MusicTestCollections.HTML
- MIR Evaluation project (IMIRSEL): http://www.music-ir.org/evaluation/
- MIR Evaluation eXchange (MIREX): http://www.music-ir.org/mirexwiki/index.php/Main_Page
- Survey of software tools used by the community: http://www.music-ir.org/evaluation/tools.html

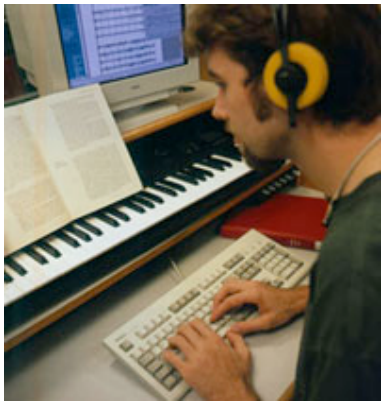
Retrieving score-like data

Digital Music Libraries, eg, Variations 2: http://variations2.indiana.edu/research/

User interface allowing: easy navigation through musical content, editing and tagging of content

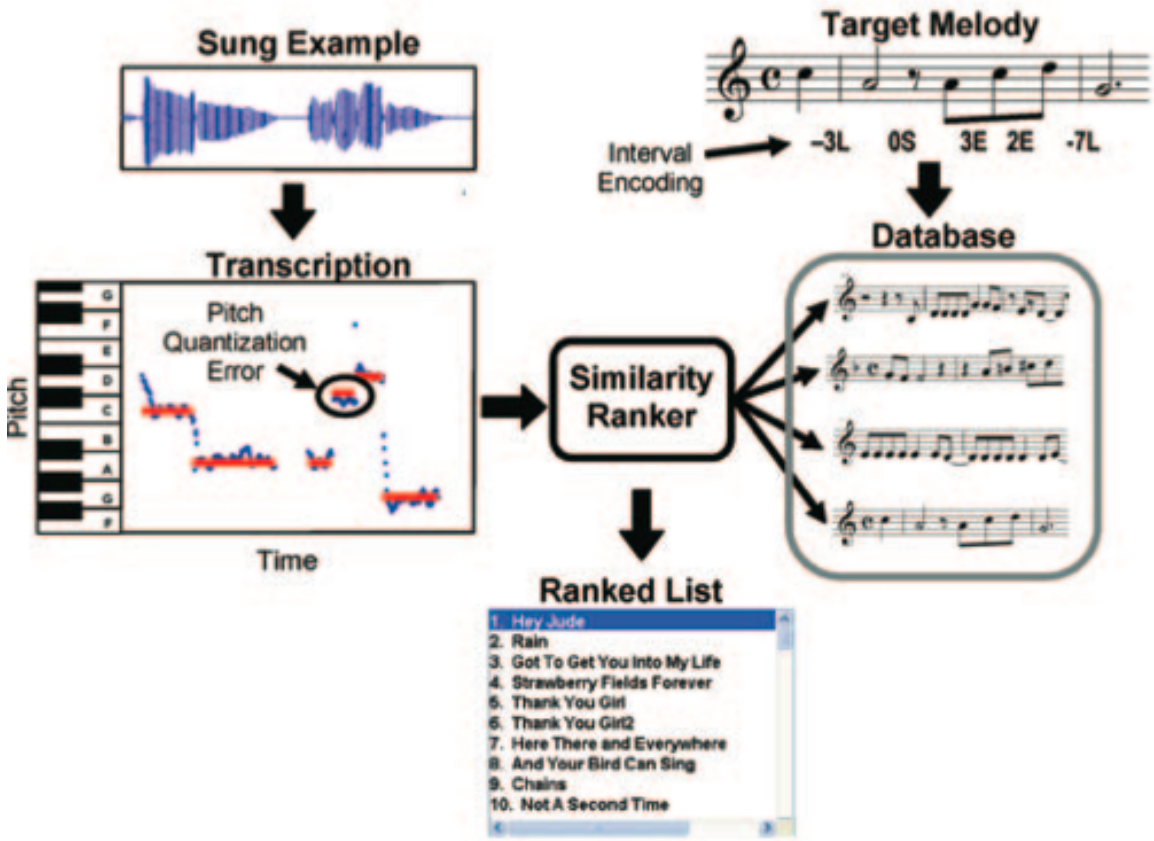






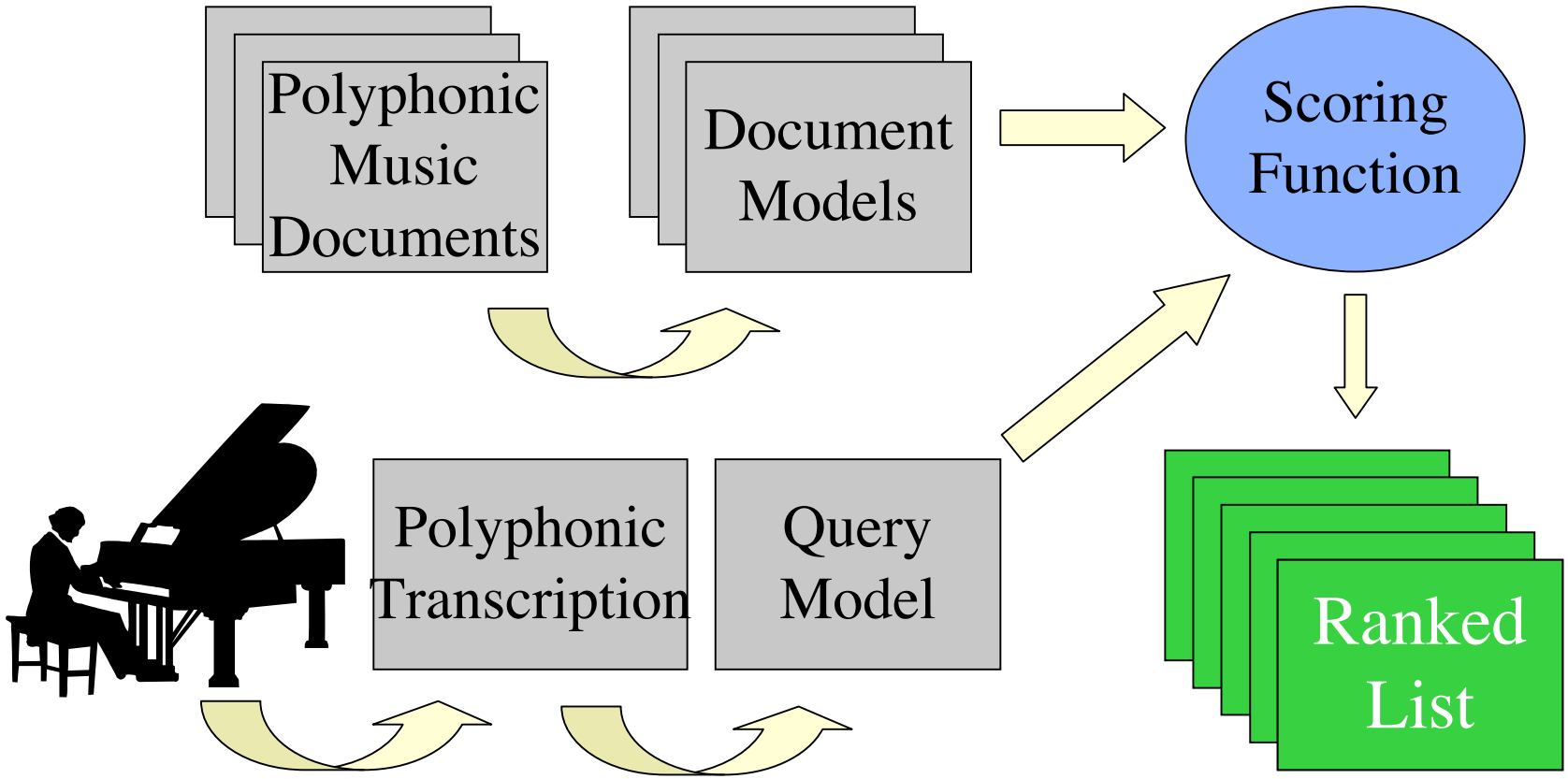
Query by humming (QBH)

- VocalSearch: http://musen.engin.umich.edu/research
- NYU QBH: http://querybyhum2.cs.nyu.edu/index.php?p=about



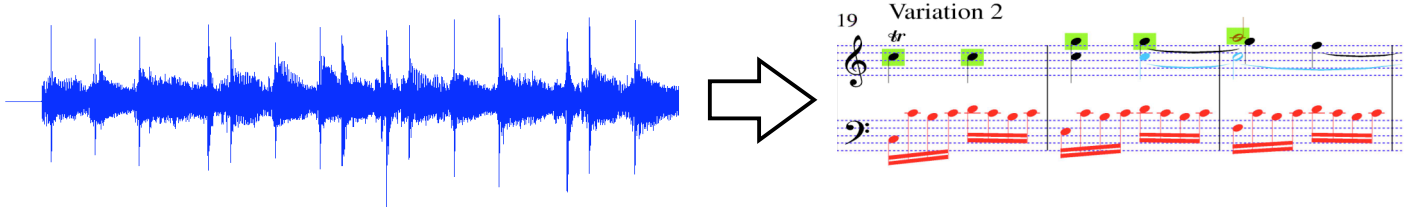
Polyphonic queries

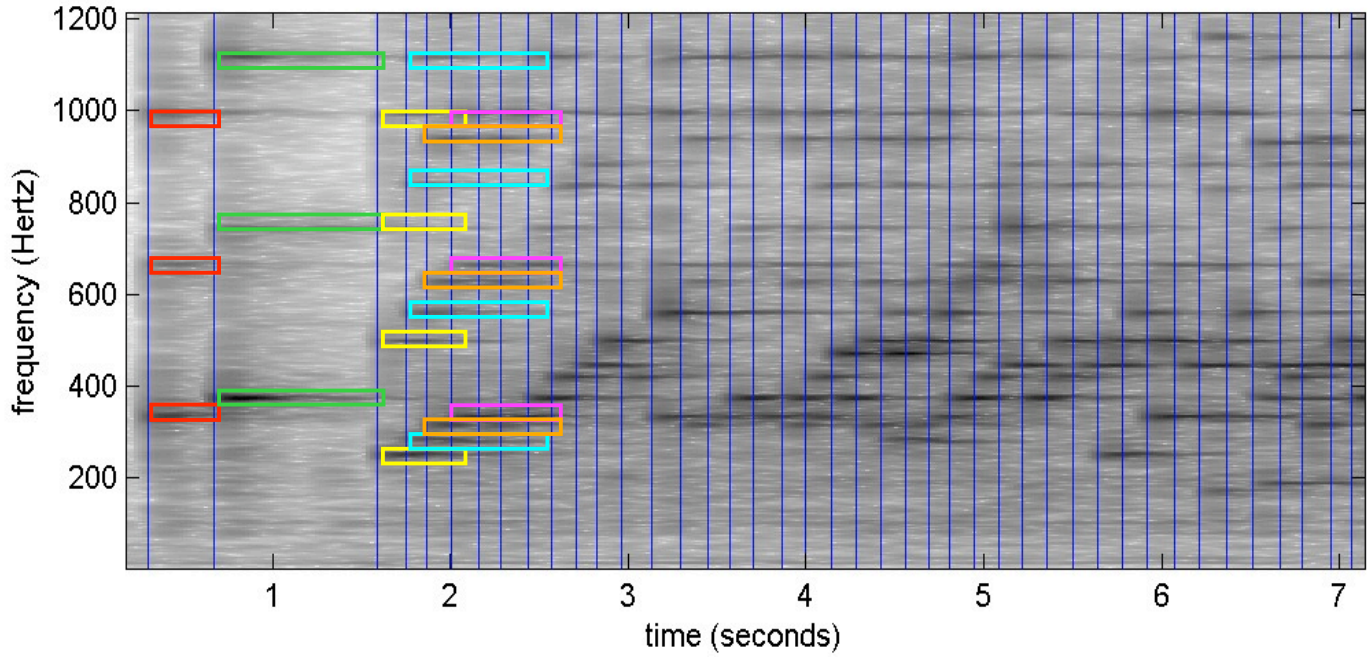
- OMRAS: www.omras.org/
- finding different performances and variations of a piece
- Retrieval of polyphonic music at the symbolic level (MIDI)
- Needs automatic music transcription



Automatic Music Transcription

- Is the process of automatically turning a recorded audio signal into an encoded score representation (e.g. MIDI).





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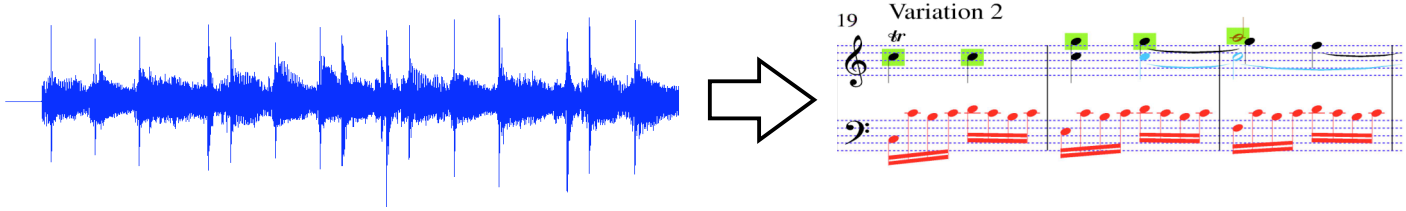
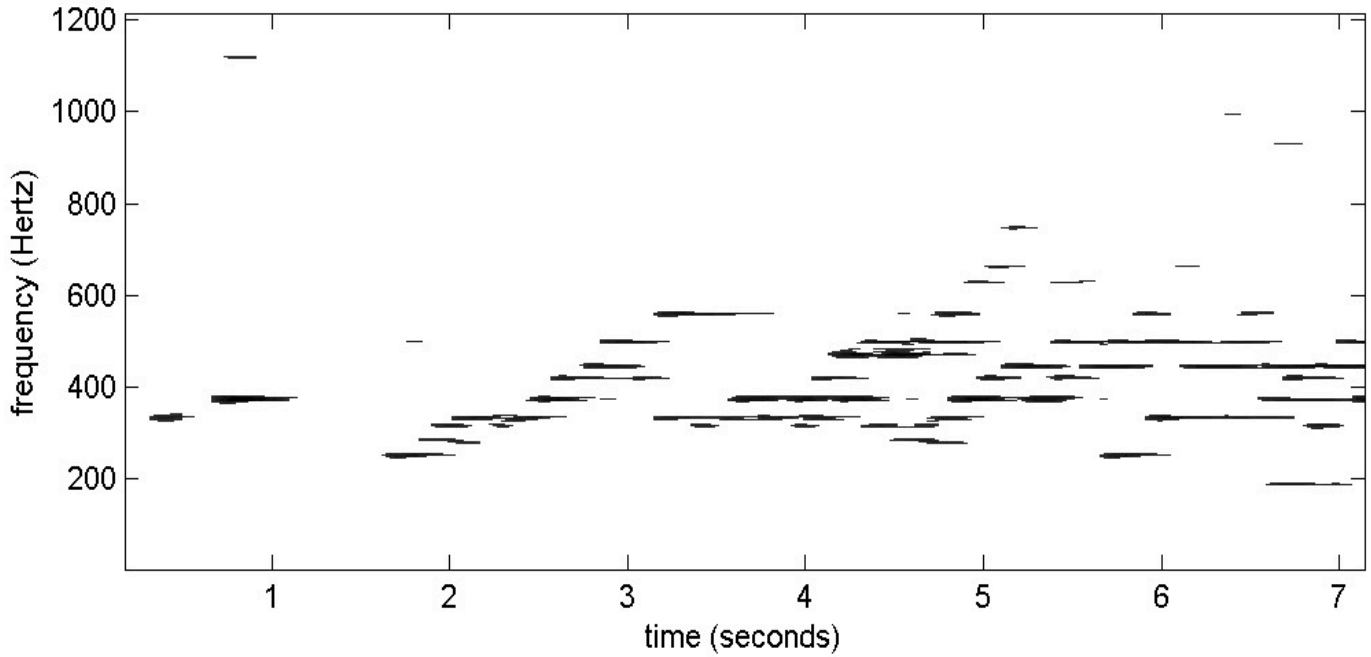
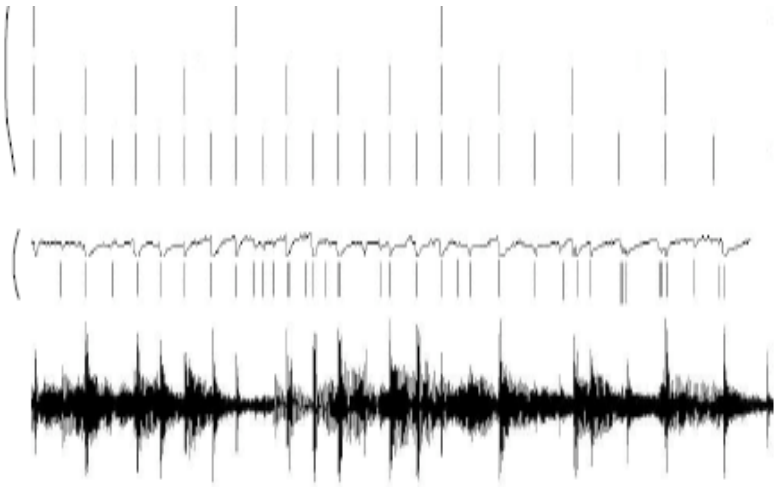
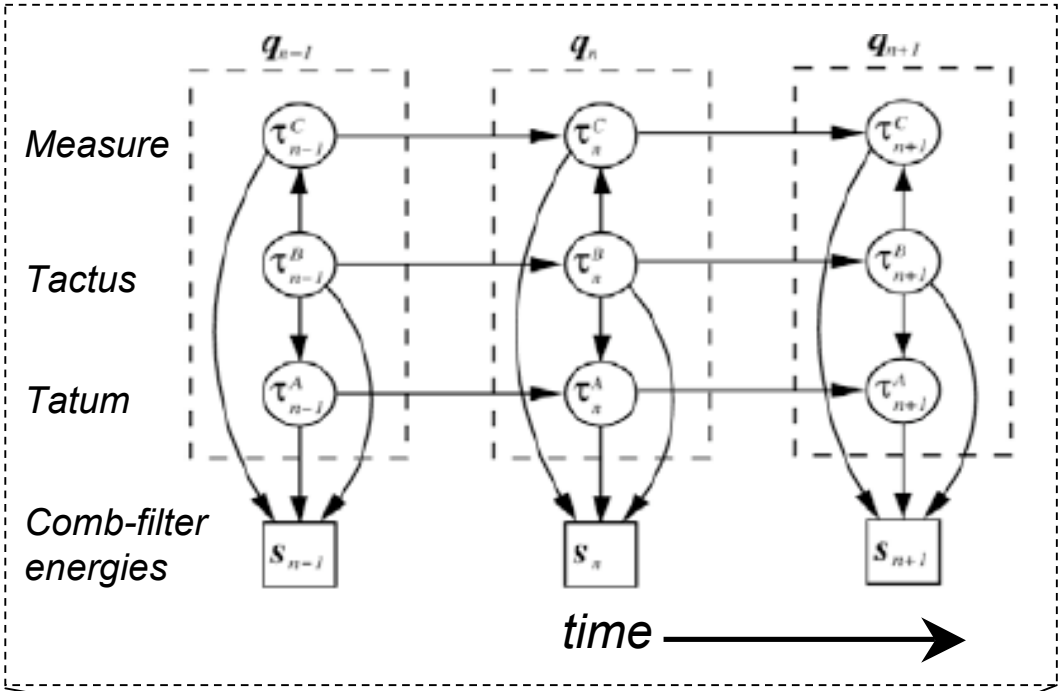




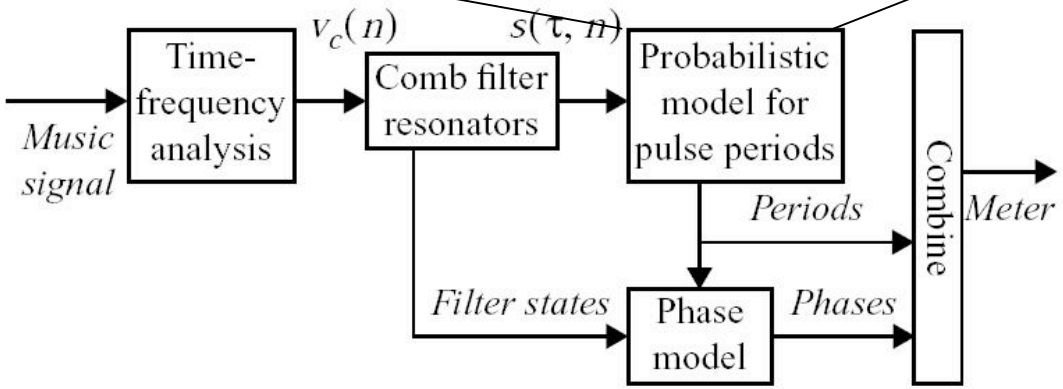
Rhythm analysis





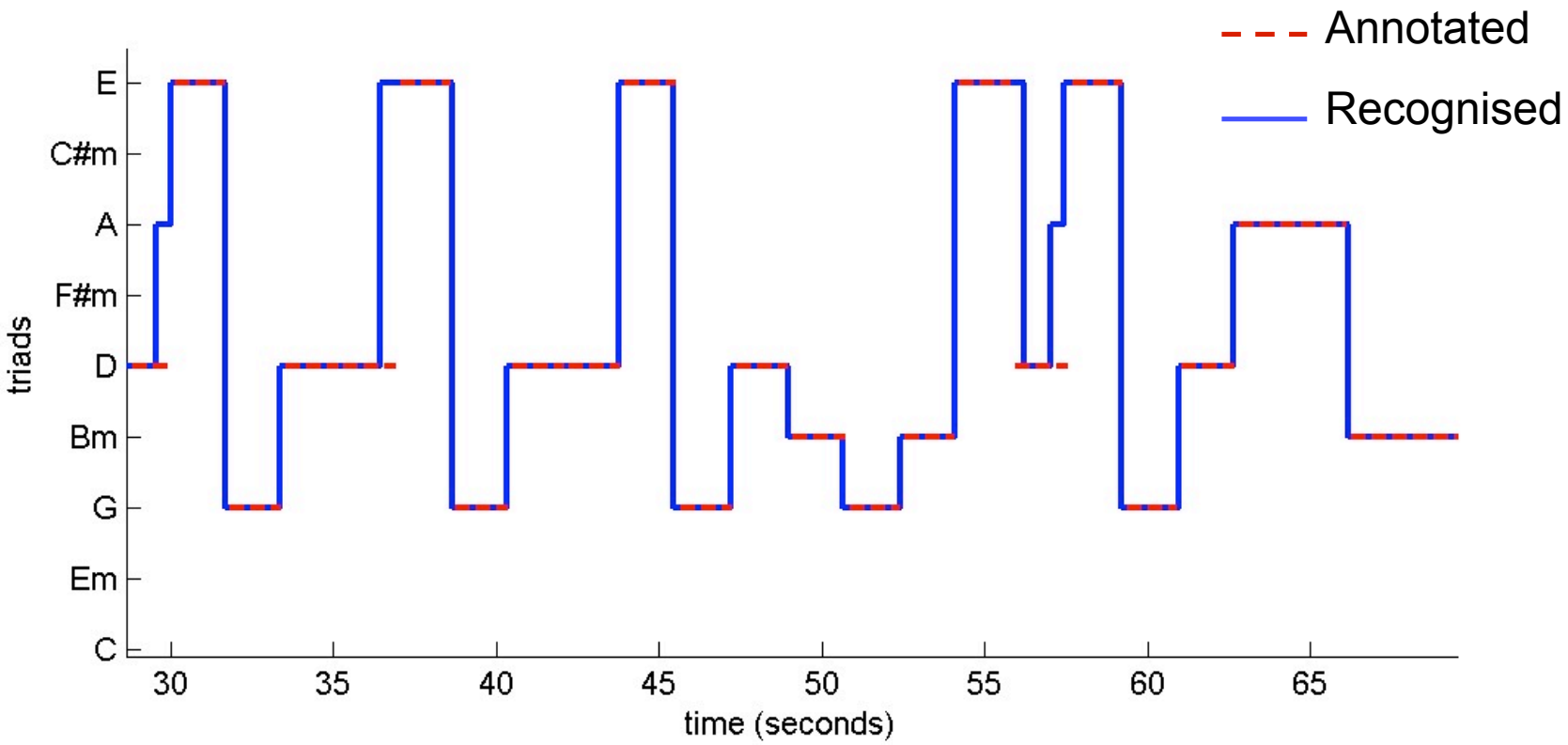
Estimating onsets, beats, meter, swing, rhythmic pattern, etc

Klapuri's hierarchical system for meter estimation (2003)



Chord estimation

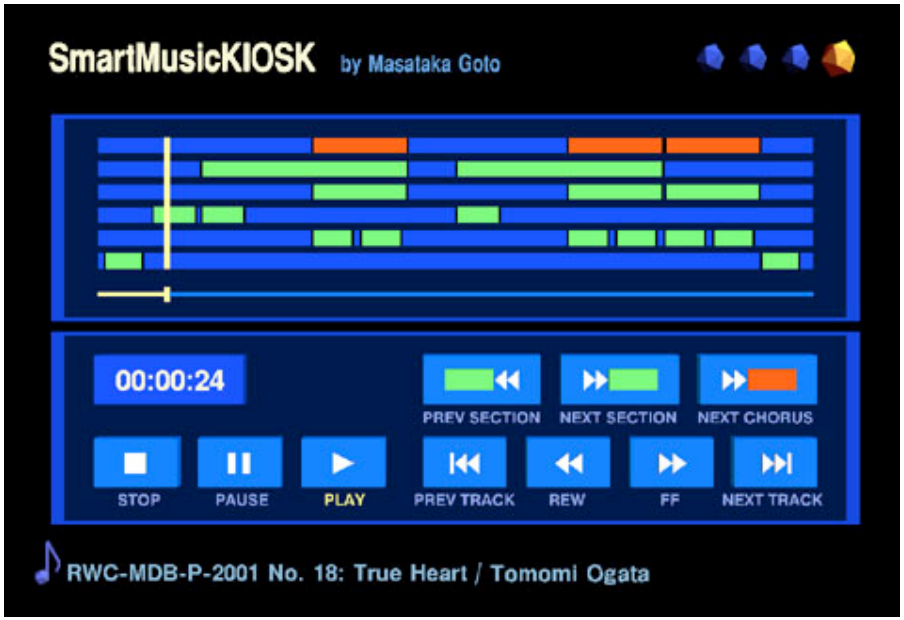
- Eight days a week – The Beatles



Bello and Pickens (2005)

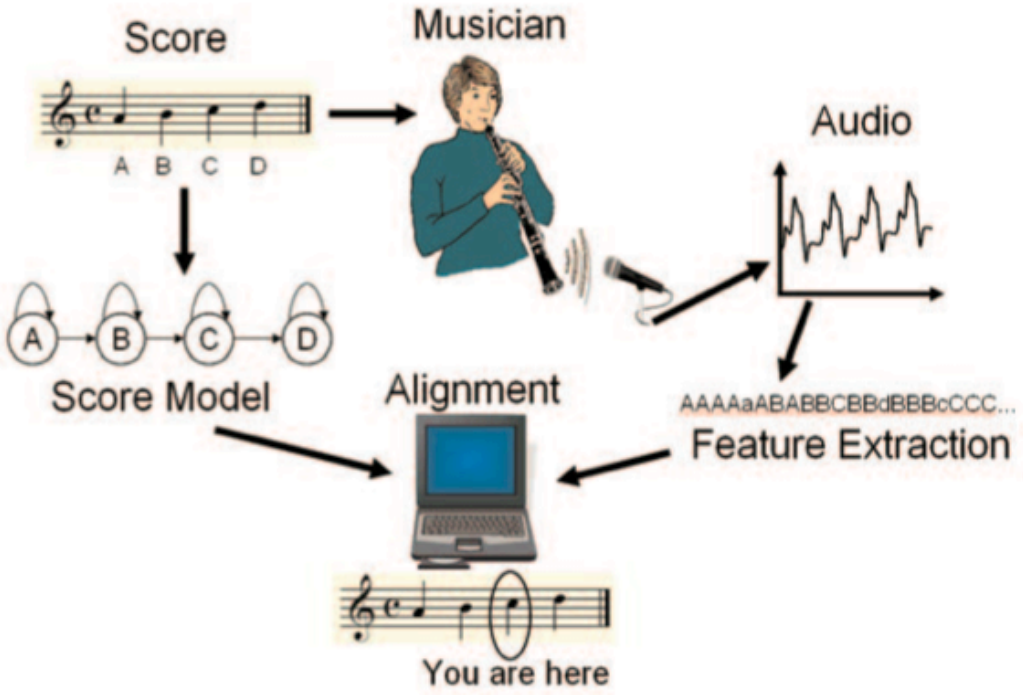
Segmentation

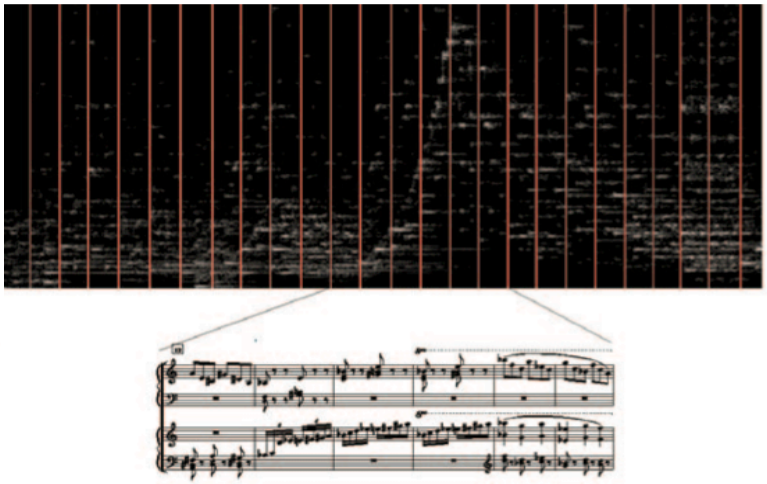
- Finding the chorus of a recorded song
- Navigating though the different sections



Masataka Goto (2003)
http://staff.aist.go.jp/m.goto/SmartMusicKIOSK/

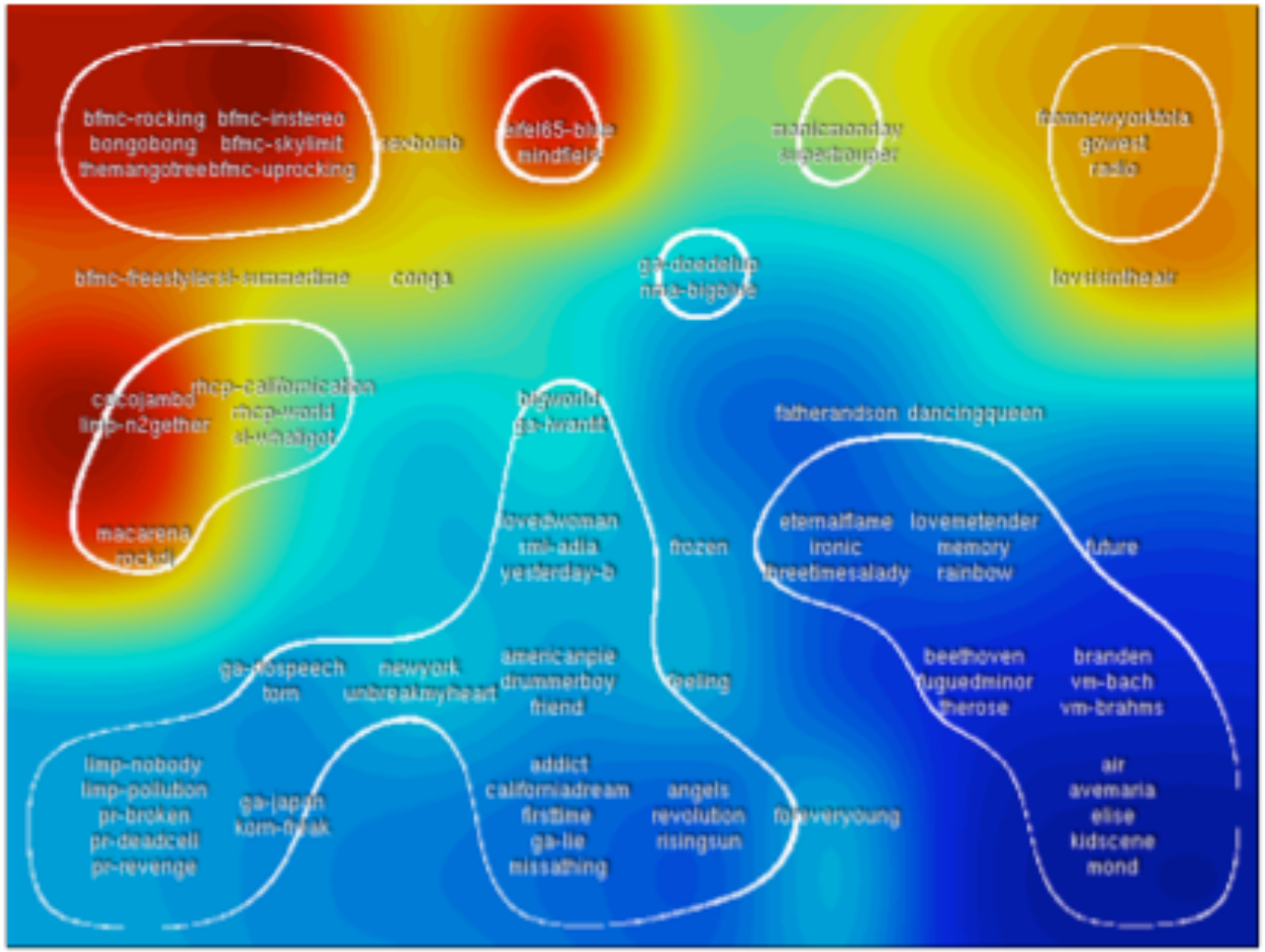
Score following





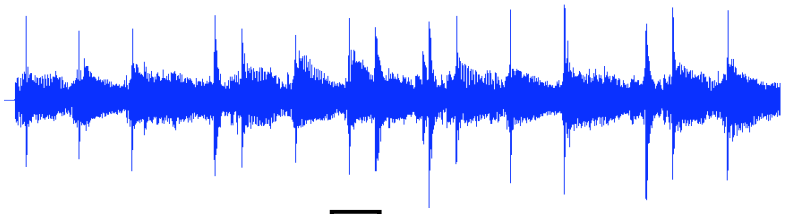
http://xavier.informatics.indiana.edu/~craphael/music_plus_one/mpo.html
http://www.cs.cmu.edu/~music/accomp/index.html

Similarity and Visualization

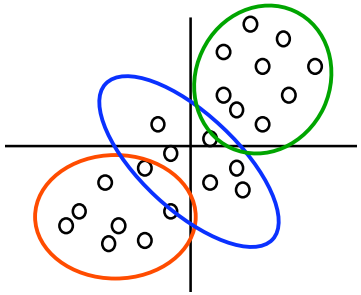


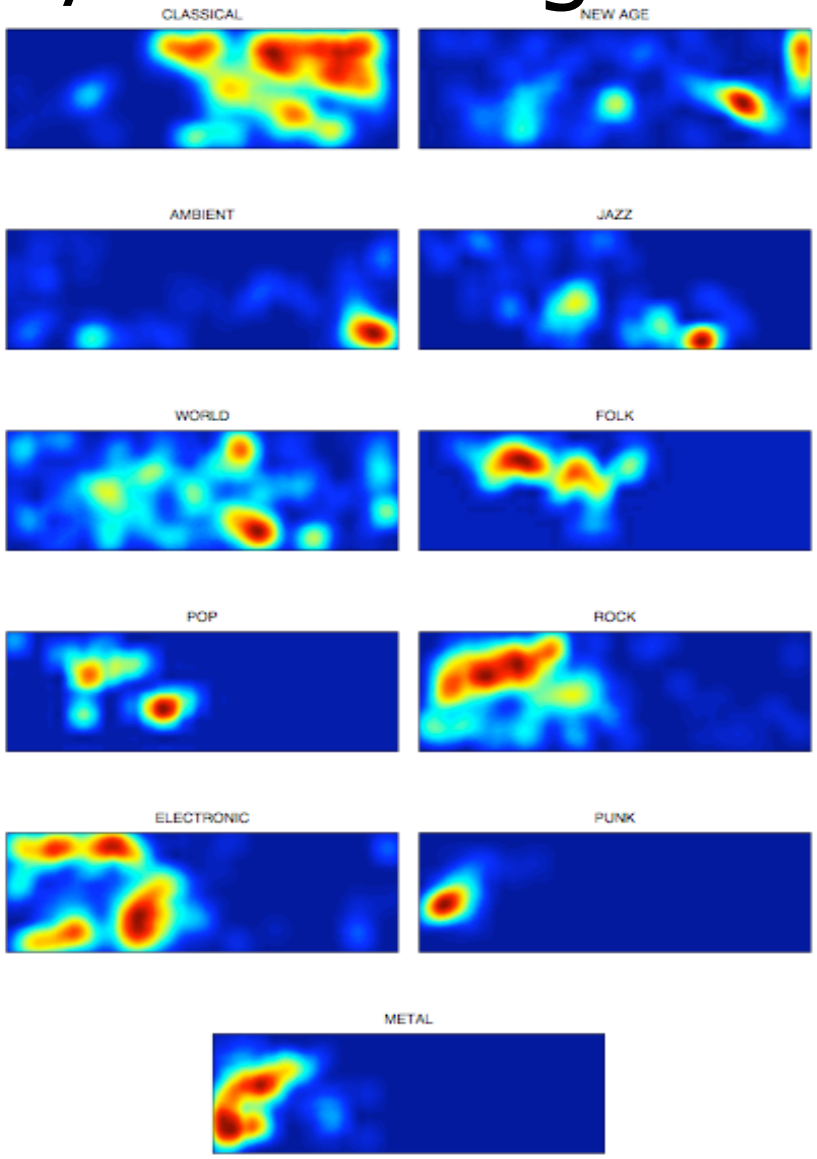
Islands of Music by Pampalk

Music Classification/Clustering



Low-level feature set (e.g. MFCC)

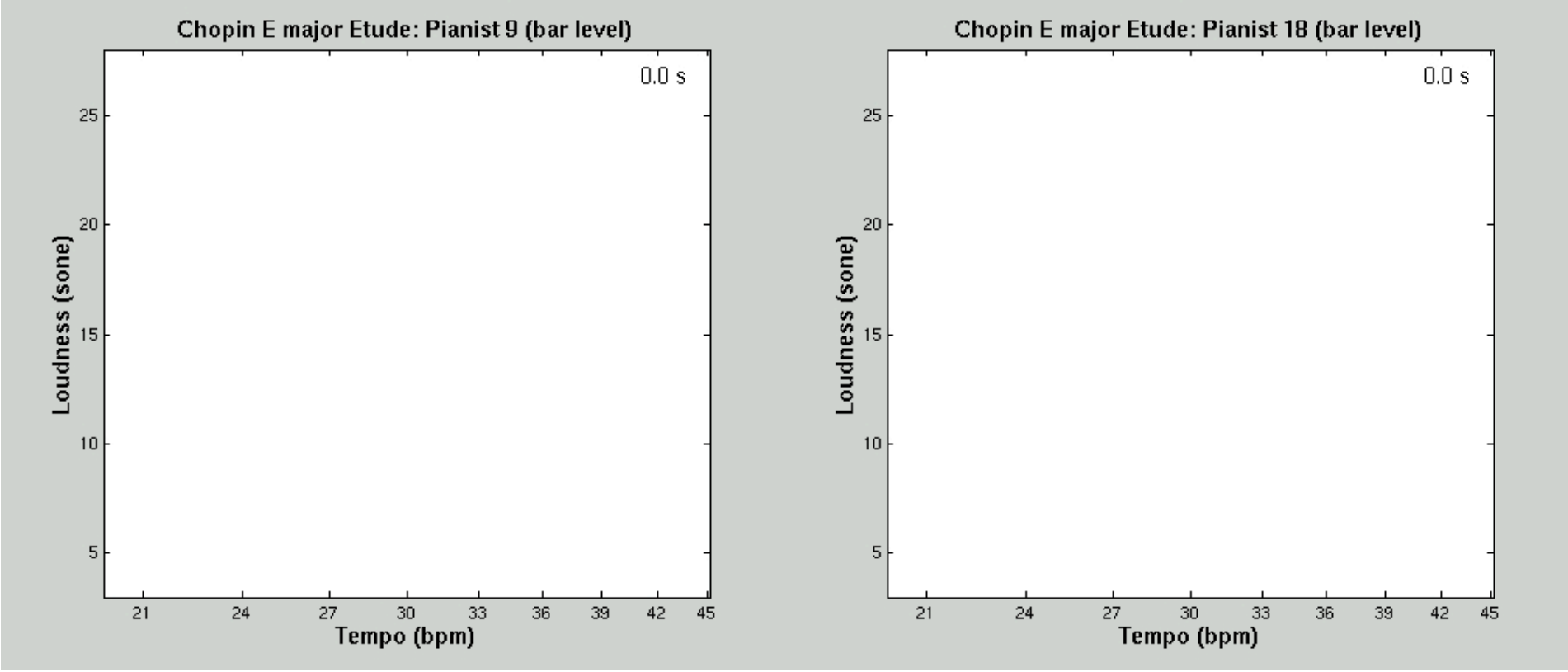




http://www.cs.uvic.ca/~gtzan/
http://www.ofai.at/~elias.pampalk/

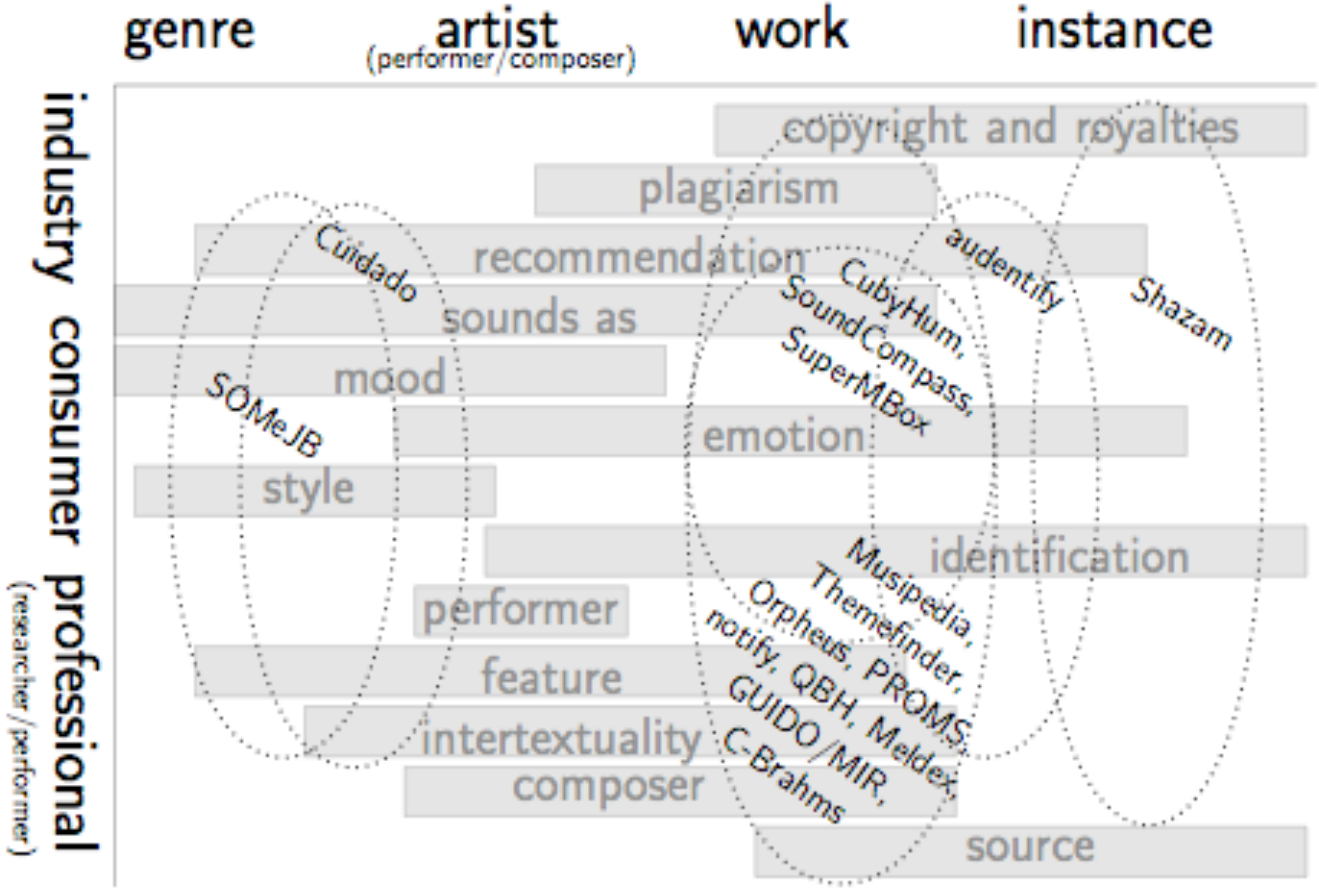
Performance Analysis

- Animations of performance (Jörg Langner & Werner Goebl, 2003)



- MIR Art? http://www.soundspotter.org/

MIR systems' survey (Typke et al, 2005)



- http://mirsystems.info

MIR systems' survey (Typke et al, 2005)

Name	Input		Matching					Features								Indexing	Collection Size (Records)
	Audio	Symbolic	Audio	Symbolic	Exact	Approximate	Polyphonic	Audio Fingerprints	Pitch	Note Duration	Timbre	Rhythm	Contour	Intervals	Other		
audentify!	•		•			•	•	•								Inverted files	15,000
C-Brahms		•		•	•	•	•		•	•		•		•		none	278
CubyHum	•			•		•								•		LET	510
Cuidado	•		•			•	•				•	•			•	not described	works for > 100,000
GUIDO/ MIR		•		•		•			•	•		•		•	•	Tree of transition matrices	150
Meldex/ Greenstone	•	•		•		•							•	•		none	9,354
Musipedia	•	•		•		•							•			Vantage objects	> 30,000
notify! Whistle	•	•		•		•			•			•				Inverted files	2,000
Orpheus		•		•		•	•		•	•		•		•		Vantage objects	476,000
Probabilistic "Name That Song"		•		•		•								•	•	Clustering	100
PROMS		•		•	•	•			•			•				Inverted files	12,000
Cornell's "QBH"	•			•		•							•			none	183
Shazam	•		•		•		•	•								Fingerprints are indexed	> 2.5 million
SOMeJB	•		•			•	•								•	Tree	359
SoundCompass	•			•		•			•			•				Yes	11,132
Super MBox	•			•		•			•			•				Hierarchical Filtering	12,000
Themefinder		•		•	•				•				•	•		none	35,000

The MIR class

Juan P. Bello

- Office: 409, 4th floor, 383 LaFayette Street (ext. 85736)
- Office Hours: Wednesdays 2-5pm
- Email: jpbello@nyu.edu

- Course-info: Mondays 4.55-6.35pm (Studio E)
  E85.2623: Music Info retrieval
  Course materials at:
  http://www.nyu.edu/classes/bello/MIR.html

Lectures tentative schedule

- 09/10. Introduction to MIR
- 09/17. DFT and the Phase Vocoder
- (09/24. ISMIR) - Assignment 1 due (weds 09/26)
- 10/01. SMS and low-level features
- (10/08. No classes)
- 10/15. Source-filter modeling: channel vocoder, LPC and Cepstrum - Assignment 2 due (weds 10/17)
- 10/22. Rhythmic analysis: onsets, beats and meter - Project pre-proposal
- 10/29. Pitch estimation
- 11/05. Student Presentations
- 11/12. Pitch estimation (cont.) - Assignment 3 due
- 11/19. Chroma features, chords and key estimation
- 11/21. Structure and Segmentation - Assignment 4 due
- 11/26. Sound Classification: genre, artist and instrument ID; similarity
- 11/28. Project Phase 1 (during office hours)
- 12/03. Classification (cont.)
- 12/10. Project Q&A @ my office (see above)
- 12/17. Project demonstrations - Final Report

Evaluation

- Matlab assignments = 40%
- Review Presentation (State of the Art in MIR) = 20%
- Project = 40%
- Attendance and class participation = ?%

- 10/22: 2-page Project Pre-Proposal: this document should include a project title and extended abstract (introducing the topic, the problem and a brief workplan), the group members and a full bibliographic reference to the paper to be reviewed.
- 11/05: Student Presentations: oral presentations of the review papers. See instructions below.
- 11/28: Project Phase 1: Open a web-page for your final project. Write a set of efficient and well-documented functions that execute the signal processing part of your project (feature extraction). All groups are required to attend office hours during this week to discuss the current status of the project, preliminary results, implementation problems and possible solutions.
- 12/10: Project Q&A: Informal session during class hours where students can ventilate any last minute problems with their projects.
- 12/17: Project demonstration and final report (both a written report and source code should be handed in).

To-do and Resources

- INSTALL MATLAB or OCTAVE ASAP!
- Matlab documentation, tutorials, examples: www.mathworks.com/access/helpdesk/help/techdoc/matlab.html
- Signal Processing Toolbox documentation, tutorials, examples: www.mathworks.com/access/helpdesk/help/toolbox/signal/
- Matlab file exchange: www.mathworks.com/matlabcentral/fileexchange/loadCategory.do
- Octave download, documentation, Wiki, FAQs: www.gnu.org/software/octave/octave.html
- Matlab sessions tuesdays 10-12 (As part of DST)

- START LOOKING FOR TOPIC:
- ISMIR home (online proceedings, mailing list): www.ismir.net
- MIR home: www.music-ir.org
- Communications of the ACM - Special issue on MIR: http://portal.acm.org/toc.cfm?id=1145287&type=issue&coll=GUIDE&dl=&CFID=15151515&CFTOKEN=6184618
- Books and specific papers as we proceed

- USE THE OFFICE HOURS