

## Music Information Retrieval and Musicology: What do the two have in common?

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Musical Heritage, Oslo, 11 December 2010

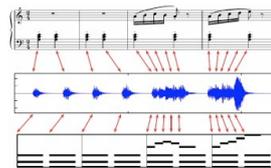


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## Topic

- two disciplines
  - Music Information Retrieval
  - musicology
- what is the relationship?
  - meaningful to musicology?
- implications for digital editions
  - **data-richness**



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## Preliminary descriptions

- Music Information Retrieval (MIR)
  - delivering the *right* (digital) music in answer to a user need
  - *right*: matching the user's taste, expertise, emotional state, activity, and cultural, social, physical and musical environment
  
- musicology
  - understanding music in its context
  - e.g. personal, social, economic, historical, theoretical
  
- MIR versus musicology
  - delivery vs. understanding
  - generic vs. specific



## Music

- universe of music
  - > 25,000,000 unique items
  - individuals can recognise several 1000s of items
  
- different views of music
  - object, digital or otherwise
  - product
  
  - work of art
  - process in time
  - mental process
  - social phenomenon



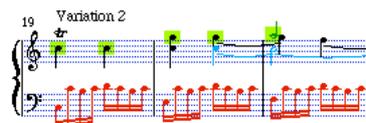
## MIR as a discipline

- emerged in 1960s (Kassler 1966), maturing since late 1990s
- definition (Downie 2004)
  - a *multidisciplinary* research endeavor that strives to develop innovative content-based *searching* schemes, novel *interfaces*, and evolving *networked delivery* mechanisms in an effort to make the world's vast store of music *accessible* to all
- contributing areas (Futrelle and Downie 2002)
  - computer science, information retrieval
  - audio engineering, digital sound processing
  - **musicology, music theory**
  - library science
  - cognitive science, psychology, philosophy
  - law



## MIR as a community

- International Society for Music Information Retrieval ([www.ismir.net](http://www.ismir.net))



- annual ISMIR conference (since 2000)
  - 250-300 attendants/year
  - Open Access to full papers
    - <http://www.ismir.net/proceedings/>
    - 1058 entries in database



# Selected MIR topics and applications

- search engines
  - Query By Humming; folksong and thematic databases
- audio identification
  - fingerprinting of *instances*
- audio classification
  - genre, artist, emotion
- audio alignment
  - syncPlayer, automatic accompaniment, performance study
- tagging and recommendation
  - labelling by end users, user profiling and push technology
- supporting technology
  - audio transcription, interfaces, visualisation



**Anonymus**  
 Ah vous dirais-maman

**Anonymus**  
 Confidencio, La. Arr.

**Anonymus**  
 Variations

**Monteverdi**  
 Variations

**Fux, Peter 1753-1831**  
 Variations

**Stieffens, [Alexandre] 1769c-1855**  
 Variations

**Janitsch, [Anton?] 1753-1812**  
 Variations

**Vogler, [Georg Joseph] 1749-1814**  
 Variations



# Some commercial services

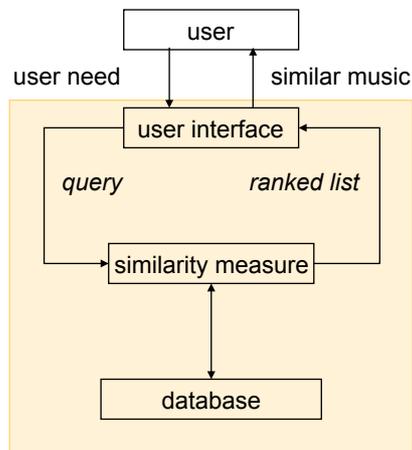


- What is Cloudspeakers
- ⊙ Let us know who your favourite bands are
  - ⊙ Discover new music
  - ⊙ Get email updates with latest music content

TRY NOW!



## Search engine architecture



- generic IR model, applied to music
- main components
  - database
  - user interface
  - similarity measure: compares query to database items
- database may contain
  - musical content
    - audio
    - notation encoding
  - metadata/tagging



## Musical data

- representations
  - audio (various formats)
  - symbolic encodings (notation-like formats such as MIDI and MusicXML)
  - scans of music notation: generally not very useful (but: OMR research)
- problems
  - rights, especially on recordings
  - too many symbolic formats, interchange difficult
  - polyphonic audio transcription
  - over- and underrepresentation of genres
  - shortage of high-quality data



## Often-used collections

- most widely used
  - personal MP3 collection
- used by many
  - RWC (royalty-free composed and performed!)
  - CCARH and Humdrum encodings of classical works
  - Essen folksong encodings, other folksong collections
  - Chopin piano recordings
  - Beatles and Real Book chord labels
  - Classical MIDI, e.g. J.S. Bach chorales
- sometimes used
  - Baroque organ fugues
  - Renaissance polyphony
  - lute music



## Music similarity

- MIR is about delivering the *right* music
  - right: 'similar' to a user need
  - often a given unit/units of musical content
- similarity is fundamental concept
  - not a lot of musical knowledge available
  - some cognitive research
- multi-dimensional
  - involves features such as
    - melody
    - harmony
    - rhythm, metre, timing
    - timbre, scoring



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- multilevel
  - from motif to 'genre'
- examples
  - cover songs
- allusion



## Pattern matching

### Themefinder

[ About | Search options | Help ]  
[ New Links | Composers | Random ]

Take the Quartet Quiz

<p><b>Repertory</b> <input type="text" value="ALL"/></p> <p><b>Pitch</b> <input type="text"/></p> <p><b>Interval</b> <input type="text" value="m2+M2P1-M2"/></p> <p><b>Scale Degree</b> <input type="text"/></p> <p><b>Gross Contour</b> <input type="text"/></p> <p><b>Refined Contour</b> <input type="text"/></p> <p><b>Location</b> <input type="radio"/> beginning of theme only, or <input type="radio"/> anywhere in theme</p> <p><b>Key</b> <input type="text" value="Any"/> <input type="text" value="Any"/></p> <p><b>Meter</b> <input type="text"/></p> <p style="border: 2px solid red; display: inline-block; padding: 2px;">Submit Search</p>	<p>1 type of music to search</p> <p>2 A-G, sharp=#, flat=- e.g. C E- G F#</p> <p>3 maj=M, min=m, aug=A, dim=a per=P, fifth=5, up=#, down=-</p> <p>4 do=1, re=2, mi=3, fa=4, so=5, la=6, ti=7 (mode insensitive). e.g. 34554321</p> <p>5 up=#, down=-, unison=- e.g. / \ / or uudsu</p> <p>6 up step=#, up leap=U, down step=d, down leap=D, same=s. e.g. uUDsdu</p>
---	---

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Center for Computer Assisted Research in the Humanities

- ca. 40.000 themes
- search options include
  - pitch
  - interval
  - contour
  - rhythm
- string representation of melody
- pattern matching by regular expressions
- output not ranked by similarity



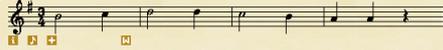
# Themefinder output

## Themefinder Results

[ 1 | 2 ] search, feedback

Matches = 11

1. Bach, Johann Sebastian (1685-1750), Jesu, Joy of Man's Desiring (from Cantata 147), 1st Movement, 2nd Theme



2. Beethoven, Ludwig Van (1770-1827), Symphony No. 9, in D Minor, Op. 125, 4th Movement, 1st Theme



3. Beethoven, Ludwig Van (1770-1827), Trio in B Flat, Vn., Cello & Pft. (Little Trio in B Flat), 1st Theme



4. Chavez, Carlos (1899 -1978), Concerto, Pft. & Orch., 3rd Movement, 1st Theme

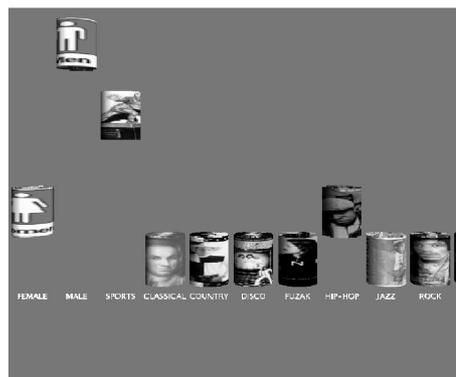


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# Genre classification using audio features

- demo created by George Tzanetakis
  - Marsyas framework
  - <http://marsyas.info/>
- low-level audio features
- output
  - limited number of classes
  - software estimates probability of class membership



GenreGram

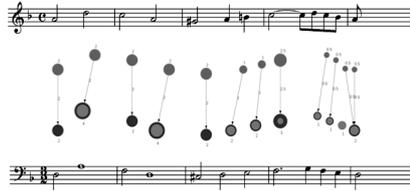


Universiteit Utrecht [http://www.youtube.com/watch?v=NDLhrc\\_WR5Q](http://www.youtube.com/watch?v=NDLhrc_WR5Q)

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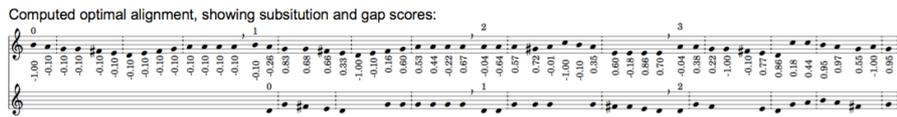
## Similarity measures

- express similarity between items as a number
- Yahmuugle
  - <http://yahmuugle.cs.uu.nl>
  - geometric model (Typke 2007)
  - models contour
- Dutch Song Database
  - <http://www.liederenbank.nl/index.php?wc=true>
  - sequence alignment model
  - models pitch, rhythm and phrase structure (Kranenburg 2010)



En daar reed eris een heer, en hij was wellegemoed En daar reed eris een heer, en hij was wellegemoed En hij droeg er d'r rozekrans on er zijn hoed En hij droeg er een ro- zekrans on erre zijn hoed.

Daar reed er een heer die was wel didelton die was wel don da don didelton Don Daar reed er een heer die was wel dergemoed



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## Witchcraft Query By Example

The screenshot shows the website interface for the Dutch Song Database. The search results for the query "Wit haert de lief - de veed omer - - - ten" are displayed. The results include the beginning of the song, the melody, and the lyrics. A red circle highlights the link "zoek vergelijkbare melodien" (search for similar melodies), which is associated with 91 songs. Other search results are also visible, such as "In Frankrijk buiten de poorten" with 58 songs.



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## Results

[En wat] baart de liefde veel smarten / En al van [...]

OPN OGL 407: opname Houtigehage 1950

*In Frankrijk buiten de poorten (2)* mp3  
transcr.

Daar reed er een heer

OPN OGL 30306: opname Enschede 1968

*Daar reed een jonkheer (1)* mp3  
transcr.

In Veendam daar staat er een herberg / Een [...]

OPN OGL 19304: opname Hoogkerk 1961

*In Frankrijk buiten de poorten (2)* mp3  
transcr.

In Veendam en daar staat er een herberg

OPN OGL 20515: opname Hoogkerk 1961

*In Frankrijk buiten de poorten (2)* mp3  
transcr.

In Frankrijk buiten de poorten

OPN OGL 26321: opname Blijham 1966

*In Frankrijk buiten de poorten (2)* mp3  
transcr.

In Frankrijk staat een herberg

OPN OGL 33312: opname Muntendam 1969

*In Frankrijk buiten de poorten (2)* mp3  
transcr.



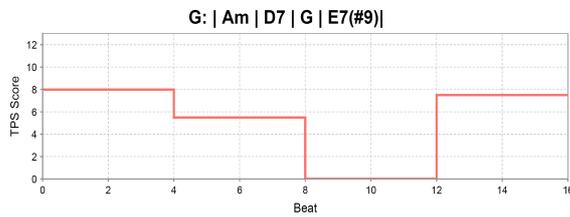
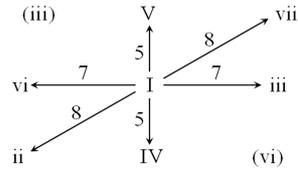
## Harmonic similarity

- harmony is a 'basic musical structure' (Temperley 2001)
- much computational research
  - chord labelling
  - n-gram modelling of sequences
- relation to melody
  - implicit harmony
  - cover songs
- interesting to investigate harmonic similarity
  - only few similarity measures exist



# Tonal Pitch Space Distance

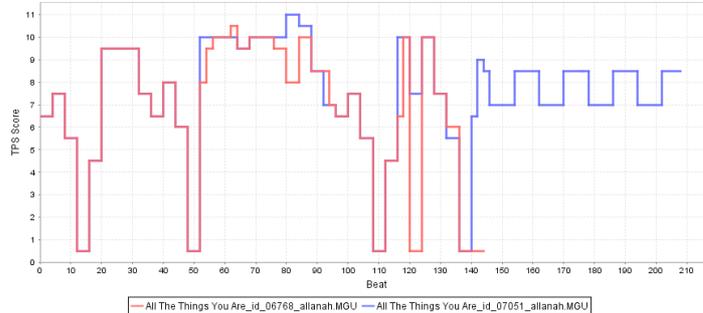
- assumptions
  - we have chord labels
  - working in symbolic domain
- calculate for each chord how far it is removed from the 'tonal centre'
  - based on music cognition (Krumhansl, Lerdahl's TPS)
- model chord sequence as step function



# Comparing step functions

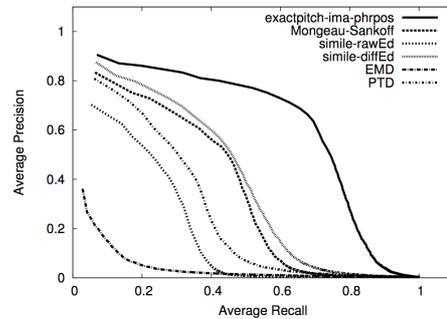
- graphs shows distance to tonal centre for 2 pieces
- shift 2 graphs such that the area between them is minimal
- normalised size of minimal area = distance
- published: De Haas et al. 2008

All The Things You Are\_id\_06768\_allanah.MGU vs All The Things You Are\_id\_07051\_allanah.MGU  
[shift 32] distance = 0.6319444



## Retrieving cover songs

- retrieve similar songs
  - use one song as query
  - calculate distance to other songs
  - order -> ranked list



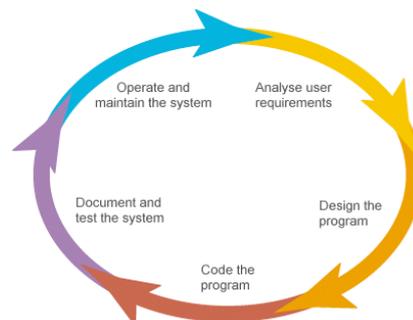
- evaluation
  - what cover songs are is determined by human experts
    - **ground truth**
  - cover songs should appear at top rank(s)
  - measure performance using TREC-like measures



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## Typical MIR research approach

- cycle of
  - modelling
  - implementation (often requiring training data)
  - empirical evaluation (requiring test data)
- resembles software development cycle



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## MIR: the big picture

- aim
  - delivering the right music
  - central role of similarity
- MIR systems
  - database
  - similarity measure
  - user interface
- lots of tools
- not so many good data collections
- multidisciplinary research
- dominant approach: computer science
  - music is data
  - quantitative, data-rich
  - ground truth
- limited role of musical knowledge



## Musicology in MIR

- musical domain experts provide
  - application scenarios
  - concepts and terminology
  - 'ground truth' for evaluation
- ground truth problem
  - MIR methods 'explain' ground truth
  - not the expertise that lies behind it
  - limited relevance to understanding music
    - no explanation of how cover songs are created or recognised



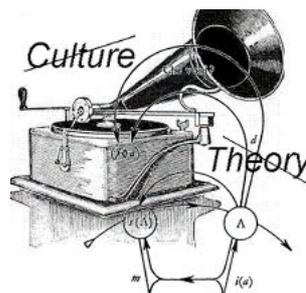
## What I'm unhappy about in MIR

- there is *a lot* to be happy about
- but there are unfortunate tendencies
  - anatomical view of music
    - static objects, information extracted
  - type of musical knowledge involved
    - traditional, creation-oriented theory
  - shallow collaboration model
    - exchange data for tools
    - no common goals
  - bad fit to present-day musicological themes



## New musicology

- crisis in 1980s from positivist to new (postmodern, critical) musicology
  - study of 'the music itself' rejected
    - 'work' concept and authorial intention in particular
  - study of musical meaning and subjectivity
- not a good time for computational approaches
- 2010: storm is over



## Musical meaning

- musical meaning used to be taboo subject
  - positivist musicology: objective study of musical materials
  - meaning and emotion considered subjective and private
- addressed in 'new musicology'
  - with notable precursors
- Lawrence Kramer (2003)
  - new musicology = cultural musicology
  - aim: understanding musical subjectivity in history
  - subjectivity: disposition to engage in specific social and historical practices
  - first and foremost about musical meaning



## Generation of meaning

- a product of action rather than structure
- emerges from a negotiation process involving musical text and context
- potential meaning resides in musical structure (Cook 2001)
- allows for many different actualised meanings
  - within a finite range



## Relating MIR and musicology

- placing music in context is hallmark of present-day musicology
- study of context strongly suggests data-rich approaches
- MIR can provide (ingredients for) these
  - long-term goal: meaningful music retrieval (Wiering 2009b)
- see also 'new empiricism' proposed by David Huron (1999)
  - postmodernism and empiricism two sides of the same coin



## data-rich approaches

- modelling human processing of music
  - apply cognitive models in analysis, artificial listening
  - historical cognition
- dealing with different instances of compositions
  - alignment of performances (Chopin, Joyce Hatto)
  - managing variants, stemmatics of 16<sup>th</sup> c. polyphony (CMME, [www.cmme.org](http://www.cmme.org))
- study of style, intertextuality and meaning



## J.S. Bach's chorales

- c. 400 4-voice settings in 'simple' harmony
  - multiple settings for many melodies, with interesting differences
- well-studied in MIR research
  - chord labelling
  - chord frequencies
  - chord sequences
  - harmonic similarity

der - mei - stes in der - welt Bach also - ber Ein - ge - gei - stes, das  
der - mei - stes in der - welt Bach also - ber Ein - ge - gei - stes, das  
der - mei - stes in der - welt Bach also - ber Ein - ge - gei - stes, das  
der - mei - stes in der - welt Bach also - ber Ein - ge - gei - stes, das

du - al - le - re Er - stig - stes, hoch - i - ber - al - le - r - Gott - o - her - Gotz, Va - ter, Sohn und  
du - al - le - re Er - stig - stes, hoch - i - ber - al - le - r - Gott - o - her - Gotz, Va - ter, Sohn und  
du - al - le - re Er - stig - stes, hoch - i - ber - al - le - r - Gott - o - her - Gotz, Va - ter, Sohn und  
du - al - le - re Er - stig - stes, hoch - i - ber - al - le - r - Gott - o - her - Gotz, Va - ter, Sohn und

heil - gei - stes, der From - men Schutz und Ret - te - r, ein We - sen, das Per - so - nen  
heil - gei - stes, der From - men Schutz und Ret - te - r, ein We - sen, das Per - so - nen  
heil - gei - stes, der From - men Schutz und Ret - te - r, ein We - sen, das Per - so - nen  
heil - gei - stes, der From - men Schutz und Ret - te - r, ein We - sen, das Per - so - nen

BWV176M6a



## Potential

- quantitative model of Bach's settings
  - regularities
  - irregularities
- irregularities may indicate unusual passages
  - particularly meaningful?
- comparison with other composers
  - attribution problems (there are some...)
  - study of imitation and influence



## Influence on Mendelssohn

- Felix Mendelssohn-Bartholdy admired, studied and performed Bach
  - aimed to integrate Bach's style into modern Romantic music
- example of influence (2 settings of nearly identical melody)



- can the 'Bach context' in Mendelssohn's works be made explicit by computational methods?
  - research challenge



## Quantifying context

- some relevant musical theory available
  - Leonard Meyer's theory of musical style (1989)
    - 'replication of patterns'
    - at 3 levels: 'laws', 'rules' and 'strategies'
  - Nicholas Cook's concept of 'potential' meaning in musical patterns
- MIR methods for pattern retrieval
  - difficult problem of pattern discovery
- could be example of 'deep collaboration'



## Computational musicology?

- term evaded so far
- what CM is (Kranenburg 2010)
  - method: studying musicological problems with computational means
  - role: mediating between musicology and computer science, MIR in particular
- CM ought not to be a separate (sub)discipline
  - subject matter, problems same as in other musicologies
  - negative effect of drawing boundaries (McCarty, *Humanities computing* 2005)



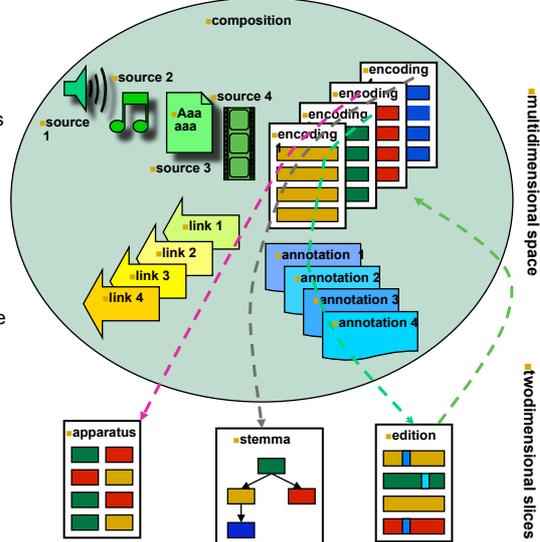
## Implications for digital editions

- potential for data-rich musicology
  - yet shortage of data
- digital editions of music are being created in many places
  - obvious resource for data-rich musicology
  - requirements of data representation
    - reusable in different context
  - requirements of content
    - appropriate to present-day topics
- what is a digital critical edition of music (DCEM)?



## A Multidimensional Model for DCEM

- a hyperlinked collection of
    - digitised sources
      - any relevant medium
    - encodings
      - information content of sources
      - central position in model
    - annotations
      - textcritical features
      - knowledge
    - link to other works
  - views reduce dimensionality, e.g.:
    - apparatus
    - stemma
    - edition: annotated path through the collection
      - may be frozen and added to collection
- high-level conceptual model  
 ■ more fully described in Wiering 2009a



## . C . M . M . E .

- Computerized Mensural Music Editing
  - initiated and led by Theodor Dumitrescu
- high-quality electronic publication of early music scores
  - free access to compositions
  - designed for Internet, using suitable technology (Java, XML)
  - dynamic edition
  - volumes
    - 1. Choirbook for Henry VIII and his sisters
    - 2. Occo-codex (forthcoming)
- <http://www.cmme.org>



## CMME: some observations

- **conceptual separation**
  - source information
  - editorial interpretation layer
  - display layer
- **variants**
  - experimental implementation
  - default version = editorial reading
  - errors are in variants
- **editing as an ongoing activity**
  - add new information as it becomes available
  - editing can become a collective project



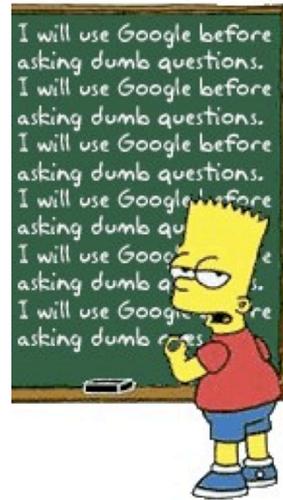
## Requirements for data-rich musicology

- **processable**
  - not an end product (visual score) but *information base*
- **information rich**
  - adds musical knowledge to score
  - resolve ambiguities
- **exchangeable**
  - so that large corpora can be created from distributed resources
- **enrichable**
  - add results (verification, further processing)
  - annotations (e.g. ground truth)
  - add links (context)
- **accessible**
  - solve any rights issues from project start



## Conclusion

- introduction to MIR
- data-rich musicology
  - merges MIR and new musicology
  - deep collaboration
  - meaning and context
- shortage of good data
- requirements for digital editions of music
  
- questions?



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