e-Science and Musicology

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Outline

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e-Science *n.*

- Become a bit of a buzzword
- Can help secure funding
- Same as/related to 'cyberinfrastructure' (common in US), 'e-Research' (common in Australia)
- Various domain-specific derivations: e-Social Science, e-Humanities

Technology for Research

- Using technology to enhance existing research methods
- Using technology to enable new research methods
- But not research into new technologies

Engineering

- Many e-Science projects are somewhat computer science engineering focused
- Often involve developing tools with which to do science
- (But the tools don't represent breakthroughs in computing research)

What Technologies?

- Distributed computing; make large scale computational resources available to scientists
- Distributed access to large scale datasets; visualisation tools
- Collaboration over digital networks

Who Likes e-Science?

- Often technologies are embraced by working scientists
- Rather than being handed down by science managers
- Potential partnerships with industry and with open source

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Three Modes of Knowledge Creation

- Computational discovery
- Comparative research
- Digital library browsing

Automation in Scientific Work

- Many accounts of (future) e-Science describe increased automation
- Cataloguing samples used in experiments
- Automated booking of experimental equipment (telescopes, microscopes)
- Automated configuration of experimental equipment based on previous similar experiments
- Monitoring and recording experimental procedures (potential for re-play)
- Automated notification of results to colleagues
- Automated retrieval of results of similar experiments
- Automated organisation of conference calls to discuss early stage conclusions

Hypothesis Formation

- In the e-Science just described, the technology is simply providing the scientists with access to knowledge and tools
- The *computational discovery* mode of e-Science would afford the technology a role in forming hypotheses

Expert Systems

- Existing AI techniques such as expert systems already make this possible (within limited domains)
- A knowledge base consists of *facts* and *rules*
- An inference engine applies logic to infer new facts from the existing facts and rules
- A natural extension of e-Science's already available large datasets

Comparative Research

- Second mode of knowledge creation is comparative research
- Executing the same (often simple) comparative operation against large numbers of data
- Knowledge comes in the form of statistical trends

Enabling Comparative Research

- Comparative research requires existence of large datasets
- Bandwidth, intuitive interfaces, and authentication mechanisms to access data (provided by sound e-Science funding)
- Mechanism to execute large number of comparison operations (e.g. distributed, parallel computing)

Digital Libraries

- Third mode of knowledge creation is use of digital libraries
- Explicitly human agents interacting with digitally encoded and delivered knowledge
- Being able to make novel connections through ease of access to diverse sources

e-Scientists

- Hints at an important consequence of e-Science
- It will require scientists to become e-Scientists
- They will have to understand the possibilities and limitations of the technology
- Concede some knowledge creation tasks to the technology

So What is e-Science?

- e for ‘enhanced’ (more than for ‘electronic’)
- Three modes of knowledge creation
- One enabled by technology (computational discovery)
- Two enhanced by technology (comparative research, digital library browsing)

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Humanities Computational Discovery

- Computational linguistics has been a core part of the AI programme from the beginning
- Results include natural language processing, computer modelling of grammars
- However, little that emulates the common formulations of humanistic research

Musicological Computational Discovery

- Similarly for musicology
- Work carried out in groups such as ISMS gives us models of human music cognition, measures of melodic similarity, or tools to identify functional harmony
- But it can't give us a feminist reading of Beethoven 5
- Or even a Schenker graph (yet!)

Humanities Comparative Research

- Corpus linguistics has a long and quite successful history
- Originally a sub-discipline, now more fully accepted
- Image comparison in archaeology (and paleography)
- Social science based heavily on quantitative (and qualitative) research enhanced by technology

Musicological Comparative Research I

- A potentially very interesting new direction for musicology
- Or maybe not so new?
- Musicology, from its inception in the C19th as a discipline concerned with the reconstruction of the music of the past through techniques borrowed from philology, ...
- ... up until the 2nd World War, was very interested in comparison
- The works of the newly formed canon were analysed for their conformance to universal rules
- And music from other cultures was analysed for its conformance (or not) to those rules
- All this was carried out through zealous comparison

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Musicological Comparative Research II

- After the 2nd World War this work was seen as too nationalistic
- Ethnomusicology advocated the study of world musics only in the context of their cultures
- Cross-cultural comparison was not valid
- Music analysis sought interest in individual works
- Cross-work comparison was not valid
- Now new techniques are making comparative studies possible again
- Especially comparative studies of performance through analysis of recordings
- However, musicologists have not yet formulated a programme of musical scholarship which requires or takes advantage of large scale comparative techniques

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Humanities Digital Libraries

- One area in which the humanities have benefited greatly from technology
- Much humanities scholarship is concerned with engaging at a very detailed level with literature
- Easy access to a good proportion of existing literature is now possible
- Projects like the Text Encoding Initiative enhance the semantic richness of this literature

Musicology's Digital Libraries

- For musicologists, a lot of scholarship is literature based
- So the same advantages apply
- However, access to musical materials (scores and recordings) has been slower to become available
- This is where techniques and efforts to produce digital editions of music are key
- Similarly, projects concerned with describing available music resources (publishing *metadata*)

Investigation Outline

- Identify research questions
- Identify information requirements
- Acquisition
- Analysis
- Evaluation
- Presentation

Identify Research Questions

- Includes both traditional research questions answered using new techniques (*enhancement*)
- And new research questions made possible by new techniques (*enabling*)
- Corpus musicology provides a good example
- As suggested earlier, formulated good research questions in the context of technologised musicology still provides fertile ground

Identify Information Requirements

- What information would you need to provide evidence to (dis)prove your hypothesis?
- How to represent and encode the information needed to answer your question?
- Collaboration; working with experts in different fields to generate research data and analytical methods
- Management of acquired data

Digression: Music from the Computer's Point of View I

- Syntax/semantics divide
- Computers can only manipulate syntax, they don't *understand* what they're dealing with
- Adding semantics to their results is up to the user
- Features: segments with semantics
- So syntactic segments can be extracted from musical data using some well-define technique
- And a semantic interpretation allows them to be interpreted as features of the music
- What do features tell us about music?
- How can we use them to answer questions about music?

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Digression: Music from the Computer's Point of View II

- The problem of tacit knowledge
- An experienced music analyst comes to a given music example with a wealth of prior experience of the musical genre
- Computers have no such prior experience
- *Except* when they are presented with a corpus; providing a context for the music example

Digression: Music from the Computer's Point of View III

- Music as information exists in different domains:
- 'Auditory', 'acoustic', 'graphemic' (after Babbit).
- Plus musical knowledge contained in texts, images, etc.
- How far can these domains be made available to the computer?

Acquisition

- Using digital music libraries (*metadata* again)
- Access to digital editions of music
- Optical music recognition
- Automatic transcription
- Motion capture of performers
- Experimentation; gathering evidence from subjects in listening tests, for example
- Surveys

Analysis

- Analysis, searching, visualisation of musical features
- Statistical analysis of surveys
- Algorithms for performing music theoretic operations on musical data

Evaluation

- Appropriate use of statistics
- Large amounts of data necessitate summarisation; patterns and trends
- It's important that those trends are credible
- Choosing helpful and unambiguous visualisations
- Applicability of findings to original research questions

Presentation

- Communicating results to a musicological audience
- Justifying your choice of statistically derived trends
- Acknowledging potential shortcomings of your method, data, analysis, etc.
- Integration of results into (public) datasets

A Mutli-domain Dataset

- The Purcell Plus project at Goldsmiths aims to apply some e-Science principles to the study of a small corpus
- The works are the *Fantazias* and *In Nomines* of Henry Purcell
- The dataset includes numerous audio recordings of each work
- Digital editions of each work
- And textual commentaries from various sources including concert programmes, concert reviews, record sleeves, record reviews, and analytical literature
- This dataset gives us the chance to apply some comparative research techniques
- The musicologist has designed the database schema for holding all the metadata for these representations

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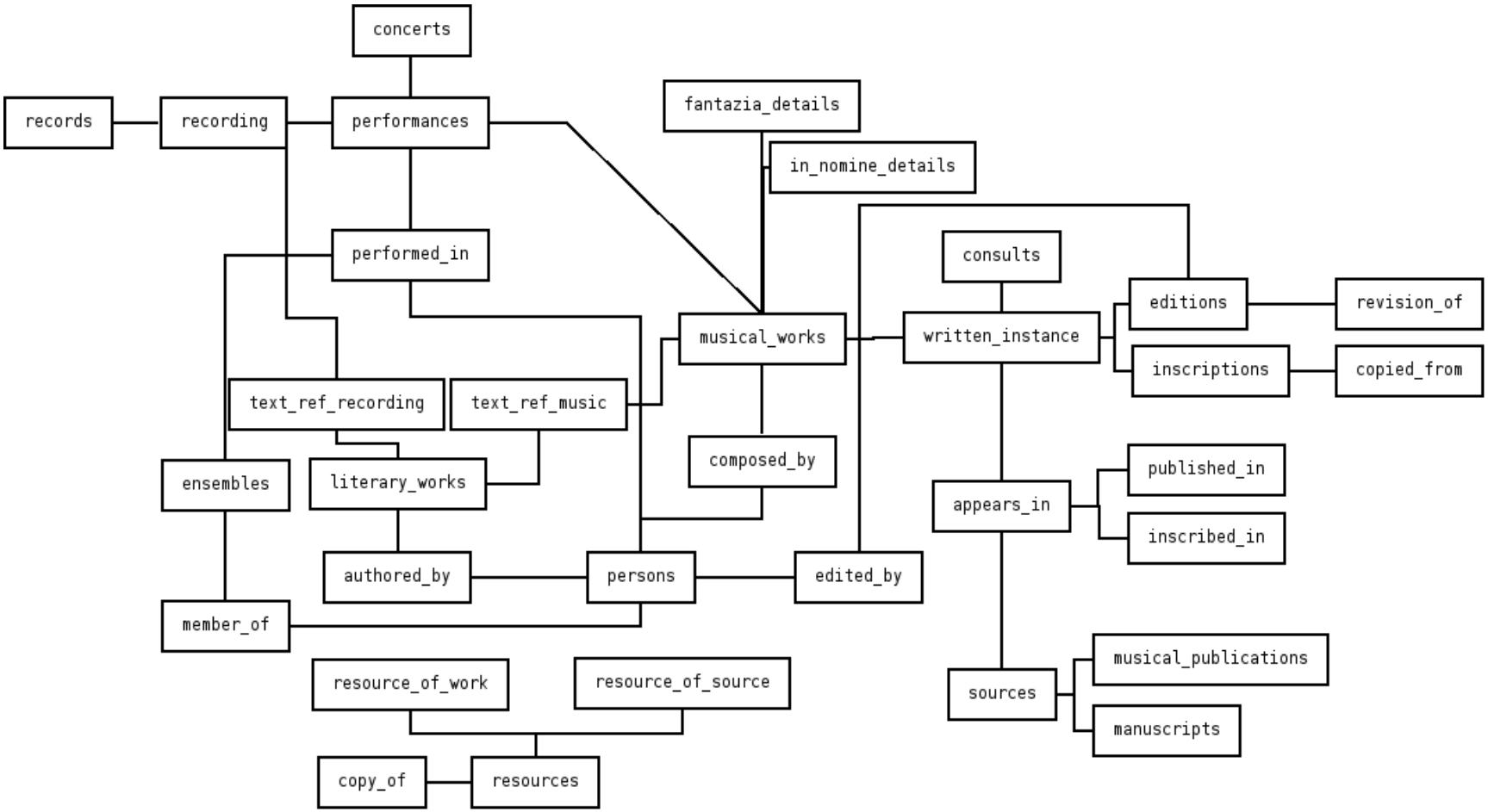
Schema



database entity relationships

Purce

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Cross Domain Linking

- Another technological requirement we are investigating is how best to encode relationships between objects in different domains
- For example, between a concert view and the work performed, and the recording of the performance
- Or between an analytical text with specific or (more difficult) vague references to parts of a work
- We are hoping to find some standards-bases solution such that our data is more easily usable for further analysis by others

Text Analysis

- We hope to attempt a computer analysis of the literature with the aim of being to assert links to works automatically
- And to be able to analyse the kinds of vocabularies that different communities of musical commentators employ
- Examples of the computational discovery mode of knowledge creation

Disciplinary Impact

- Finally, the project hopes to be able to assess the impact e-Science may have on musicology
- This workshop is part of that process!
- Along with my Ph.D thesis

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