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Music and Computational Linguistics

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Today's Talk Overview

Introduction to Computational Linguistics and Music Relationship

History & Theory Computational Applications

Audio Melody Extraction (my master thesis summary

Symbolic Melody Processing Digital Signal Processing Results

Introduction to Computational Linguistics and Music Relationship

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Totally Different View



Friedrich Nietzsche (1844 – 1900) The Birth of Tragedy from the Spirit of Music

Introduction to Computational Linguistics and Music Relationship

History & Theory

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History



Heinrich Schenker (1968 – 1935)

- Austrian composer and music theoretician
- 1903 The Tonal Theory of Music
- something as generative and transformation rules 50 years before Chomsky



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History



Leonard Meyer (1918 – 2007)

- American composer and philosopher
- in 1950's influential work about information theory in music
- musical meaning = comes from the confrontation of the listener's expectation and the reality on different levels of perception
- hypothesis: the particular levels can be modeled as Markov chains



Musical meaning arises when an antecedent situation, requiring an estimate as to the probable modes of patter continuation, produces uncertainty as to the temporal-tonal nature of the expected consequent.

- hypothetical meaning derived basically by admitting information
- evident meaning mental feedback of what just happened
- determinate meaning understanding of on architectonic level

History



Leonard Bernstein (1918 – 1990)

- famous American composer and conductor
- influenced by chomskian linguistics
- 1976 <u>Unanswered Questions</u> lectures on relationship of music and language



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Leonard Bernstein – Music Layers

LANGUAGE

Poetry (super-surface structure)

Prose (surface structure)

Underlying strings (deep structure)

Chosen elements (morphemes, words, etc.)

MUSIC

Music (surface structure)

Unobservable "music prose" (deep structure)

Underlying strings (Melodic, Harmonic and Rhytmic)

Chosen elements (key, meter, notes etc.)

History



Manzara, Witten et al.

- music remake of Shannon's experiments with English from 1940's
- people in the experiment guessed next note in melodies of Bach's chorales
- results similar as with language
- computational model yields similar entropy as human judgment → music "language" models are possible

Introduction to Computational Linguistics and Music Relationship

Computational Applications

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Machine Composition

- 1960's Hiller and Isaacson machine-generated compositions based on textbook rules
- David Cope started in 1980's, finished in 2007 a rule based system generating compositions in style of couple of famous composers

The Continuator

- project by Sony, stared 2002 still running
- continues with jazz improvisation started by humans
- random walk on dynamically adapted Markov chain



https://www.youtube.com/v/ynPWOMzossI

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Music "Parsing"

- Essen Folksong Collection big corpus of European folksongs
- contains also segmentation into phrases usually depends on prosody of the lyrics
- probabilistic context free grammars were able to parse the folksongs with 90 % accuracy



Other Tasks

- detecting plagiarism, composer detection, genre identification
- NLP-inspired algorithms edit distance, n-gram statistics etc.
- such algorithms compete every year in competition MIREX (Music Information Retrieval EXchange)

Audio Melody Extraction (my master thesis summary)

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Goals of the Thesis

- create a "language model" for melodies
- use in use it for improving performance of the automatic melody extraction

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Melody Extraction Task

sometimes hard to define what the melody is

https://www.youtube.com/v/Dr5QHUMvOSo&start=120&end=150&version=3&autoplay=1

- in MIREX competition only popular music is used for clarity, intuitive understanding is enough
- state-of-the art: DSP algorithms with somehow tuned parameters, not machine learning



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Audio Melody Extraction (my master thesis summary)

Symbolic Melody Processing

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Getting the Data

- 715 hours of music downloaded from the Internet
- various styles: renaissance, baroque, classicism, romanticism, impressionism, 20th century, jazz, rock, pop
- for further processing melody was automatically extracted

Symbolic Melody Extraction

- 1998 simple skyline algorithm
- later heuristics introduced to fix some problems
- different approach: track with the highest entropy
- 2006 corpus from University of Alicante, melody tracks annotated in MIDI files
- skyline algorithm on track classified as melodic

Melody Corpus Overview

style	melodies [hours]		
Renaissance	12:49		
Baroque	91:09		
Classicism	48:40		
Romanticism	59:58		
Impressionism	5:02		
20th century	34:54		
Classical - total	252:35		
Jazz	38:11		
Rock	33:33		
Рор	18:38		
Corpus from Alicante	66:10		
Total	408:03		

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Melody Model



- SRILM toolkit used to create the melody model
- trained and tested on the particular style specific sets
- the more data, the better no matter the styles
- renaissance is totally different, jazz kind of different

Melody Generation

 melodies can be generated – very poor, inner structure is totally missing



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Audio Melody Extraction (my master thesis summary)

Digital Signal Processing

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Algorithm Overview



Algorithm Overview



Fundamentals Detection



Harmonic Spectrum Product



Cepstrum biased Harmonic Spectrum Product

Optimization of the salience function in the whitened spectrogram



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Algorithm Overview



Partial Tracking



Algorithm Overview



Exhaustive Track Search



Audio Melody Extraction (my master thesis summary) Results

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Results

	without	with	T.VZ	
	melody	melody	simple	current
	model	model	НММ	best
voicing accuracy	0.568	0.601	0.756	0.810
raw pitch accuracy	0.231	0.104	0.579	0.692
raw chroma accuracy	0.265	0.151	0.818	0.765

 proposed algorithm even worse than the fundamentals detection left alone

simple HMM with "brutal" parameters tying and naively estimated probabilities performs much better

Where is the Problem?



What the Algorithm Actually Does? (1)



What the Algorithm Actually Does? (2)



Ideas for Future Work

Signal Processing

- finish the AME with HMM (looks promising)
- extraction of the symbolic melody from the "physical" sequence of frequencies

Symbolic Music Processing

- get better melodies from the corpus
- what about unsupervised morphology? unsupervised parsing? would results of these have explanation in musicology?
- do more with the data harmony

Thank you for your attention.

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