Music generation and manipulation

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Overview

- Different contexts for automatic generation
  - computer as supporting tool for composer
  - computer as testing tool for researchers
  - computer as interactive musical instrument
  - computer as instrument within educational/health context
  - automatic generation for games

Example

Example

History

- Process of composing itself often almost algorithmical
  - Example: canon
  - Explained by: Justin Henry Rubin, University of Minnesota Duluth

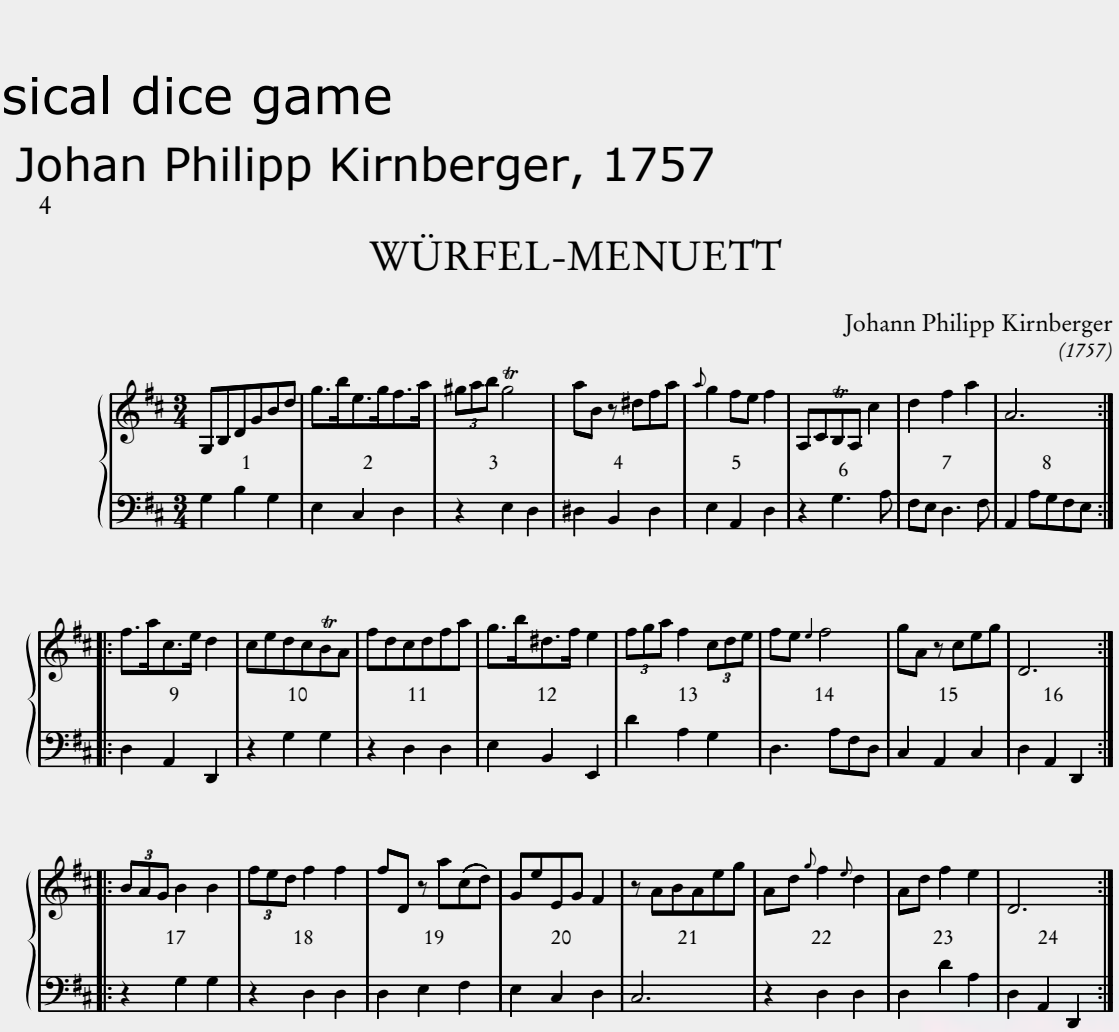
http://www.d.umn.edu/~jrubin1/JHR%20Canonic%20Examples2ab.htm

History

- Composing as constraint-based "programming"
  - Example: Palestrina counterpoint, described in Johann Joseph Fux: *Gradus ad Parnassum* *(1725)*
  - *Palestrina Pal (by Anna Huang, 2005): automatic rule checker*
  - Constraint programming in music (Truchet & Assayag, 2011), IRCAM in Paris, for supporting composer

History

- Musical dice game
  - Johan Philipp Kirnberger, 1757



History

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History

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  - Joris de Man, game music composer, ISMIR 2010

History

- Babbages' Analytical engine
  - First fully-automatic calculating machine
  - conceived in 1834, designed to evaluate any mathematical formula; part of the machine was completed before Babbage's death in 1871
  - checkout Science Museum London

History

- Ada Lovelace on Babbages' Analytical engine:
  - Supposing, for instance, that the fundamental relations of pitched sound in the signs of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent"
  - Lovelace's notes became one of the critical documents to inspire Alan Turing's work on the first modern computers in the 1940s. (http://findingada.com/about/who-was-ada/)

History

- Iannis Xenakis
  - "Formalized music", 1963
  - Stochastic methods for composing
  - Not fully automated, computer has aided the composition process
  - https://www.youtube.com/watch?v=qIGDMMN1lQI
- Mario Baroni & Carlo Jacoboni: Proposal for a Grammar of Melody: The Bach Chorales, 1978
- Kemal Ebcioglu: CHORAL (1986)
  - Rule-based approach to produce Chorals in the style of Bach

Recent examples

- Francois Pachet: Continuator
  - Computer as interactive musical instrument
  - combines techniques from interactive and automatic learning systems.
  - learns and interactively plays with a user in the user's style.
  - based on a Markov model of musical styles

Recent examples

- Francois Pachet: Continuator

https://www.francoispachet.fr/continuator/

https://www.youtube.com/watch?v=cHKcq0D5EY4

https://www.youtube.com/watch?v=ynPWOMzossI

Recent examples

- Gerard Assayag & Shlomo Dubnov: Factor oracle improvisation
  - Factor oracle
    - efficient data structure, used to model recombination aspect of musical improvisation
    - http://recherche.ircam.fr/equipes/repmus/MachineImpro/
  - Variable markov models
  - Based on "Factor oracle: A new structure for pattern matching. In: SOFSEM'99: Theory and Practice of Informatics, LNCS, vol. 1725, pp. 295–310. Springer Berlin / Heidelberg, Milovy, Czech Republic (1999)"

Recent examples

- Dorien Herremans and Elaine Chew: MorpheuS (2016)

Most recent example

- Dorien Herremans and Elaine Chew: MorpheuS (2016)
  - Dagstuhl stimulus talk, March 2016

Why don't we listen to automatically generated music?

$\Rightarrow$ Long-term structure

MorpheuS

Composing music = combinatorial optimization problem

- Decide on which notes
- Objective: fit a style/structure
- Solved by metaheuristic such as variable neighbourhood search

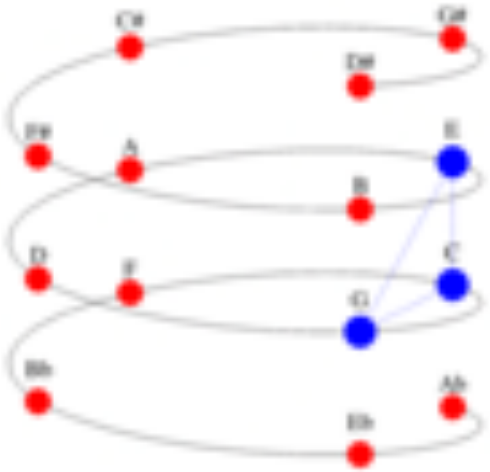
Constraints: tension and patterns

1. Structural constraints
   - Global structure
   - Tension profile
   - Pattern detection

Tonal tension

The spiral array, a 3D mathematical model for tonality

The Spiral Array (Chew, 2000) with a C major chord:



→ 3 aspects of tonal tension

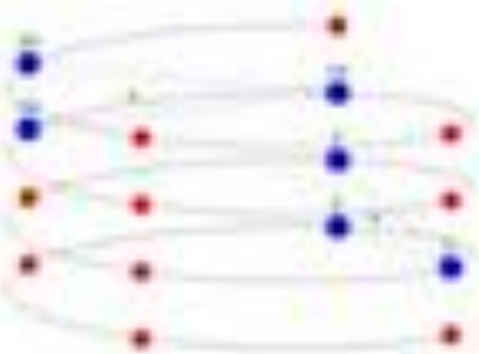
https://www.youtube.com/watch?v=bLNIiuCqeno

https://vimeo.com/151142022

Tonal tension

3 aspects of tonal tension

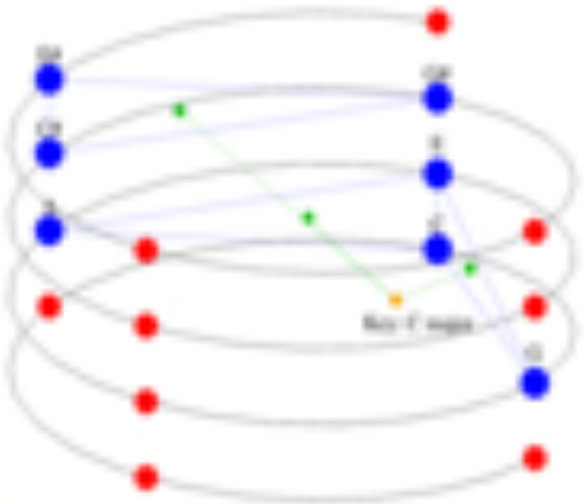
Cloud diameter



Cloud momentum

Tonal tension

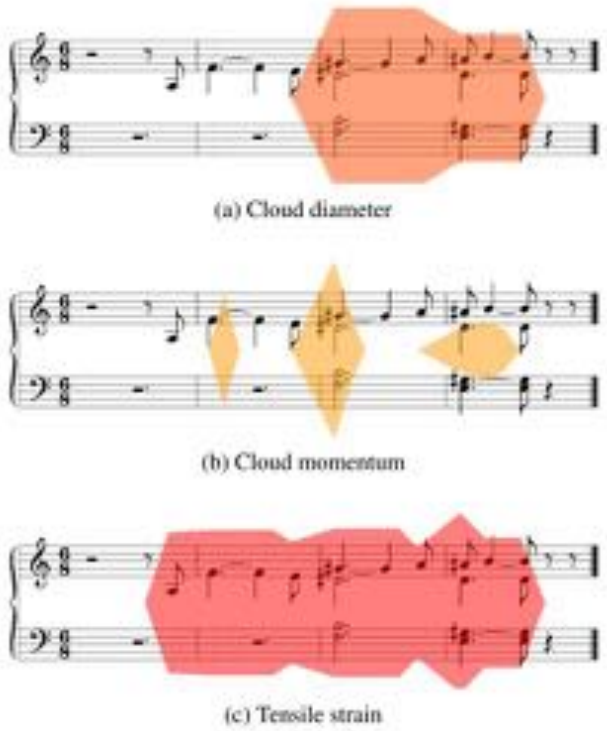
3 aspects of tonal tension



Tensile strain (distance to key)

Tonal tension

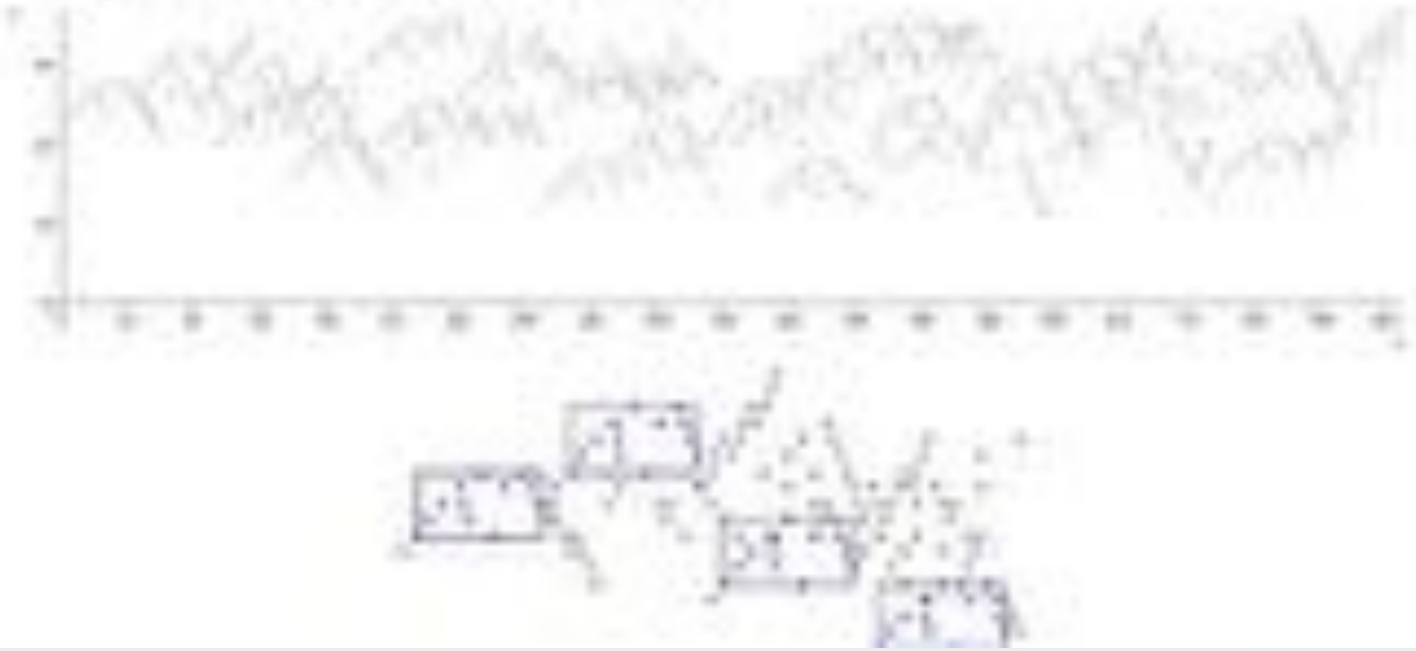
Tension profiles – soft constraints



Pattern

Pattern detection

- Compression algorithm: COSIATEC (Meredith, 2013)
- Point set representation of a piece
- Computes a compressed encoding of the piece
  → maximal translatable patterns

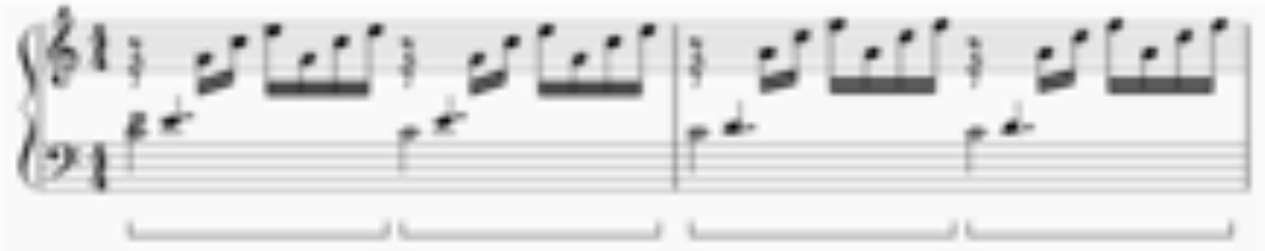


Generation

Putting it all together: MorpheuS

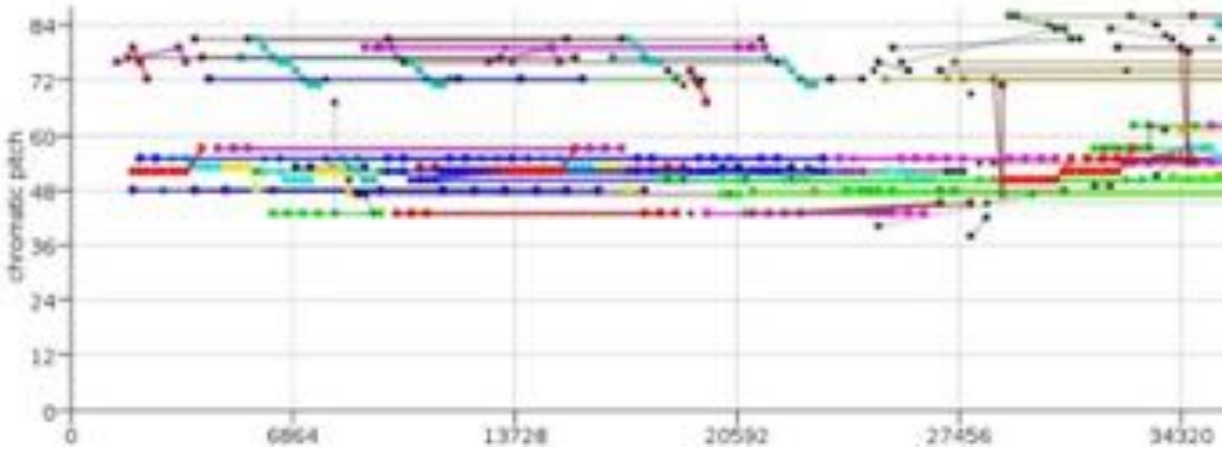
- Problem: find pitches
- Objective: match tension profile to template
- Hard constraint: detected patterns

⇒ Test: Bach 1st Prelude:



Generation

Preliminary results: pattern detection

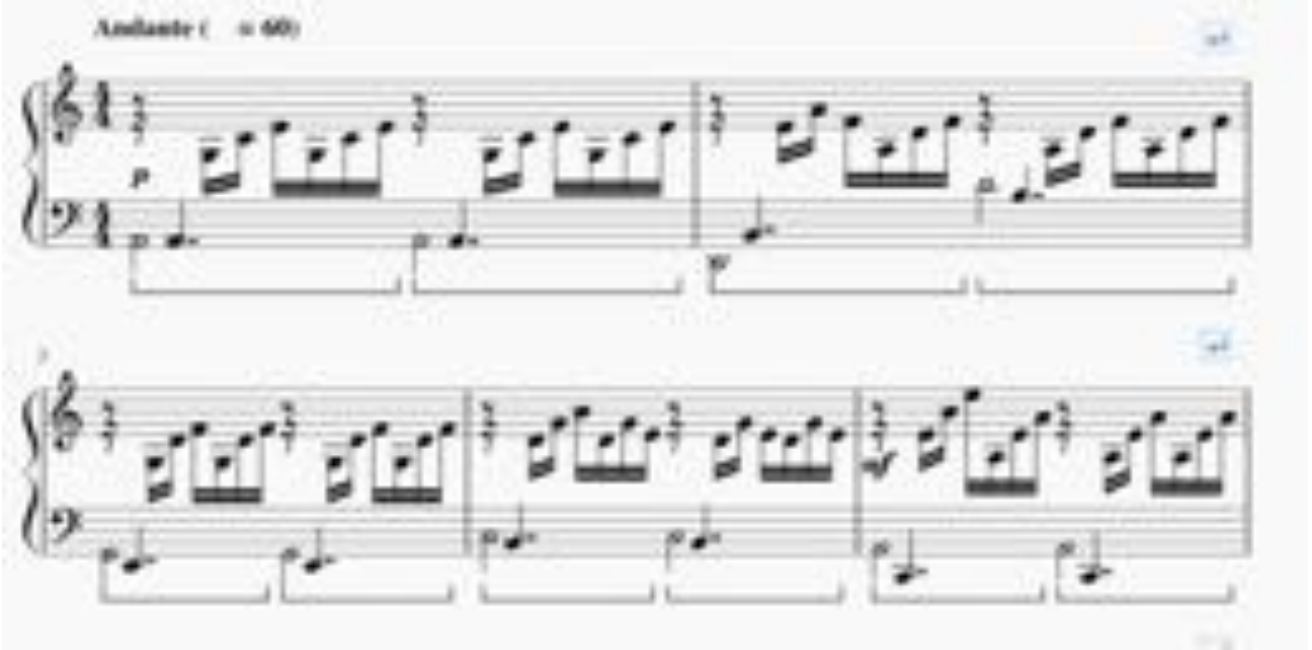


Generation

Preliminary results: random starting piece

Generation

Preliminary results: fit in tension profile & patterns



MorpheuS

- http://dorienherremans.com/morpheus

Deep Learning

- Bob Sturm – Folk RNN (student presentation)
- BachBot | Creative AI for Classical Music
- DeepBach: harmonization in the style of Bach generated using deep learning (Francois Pachet)

Companies

- Jukedeck (London), first merged with Bytedance, now with TikTok
  - AI compositions for videos
- Melodrive (Berlin)
  - Music for interactive media
  - Demos

Conclusion

- Lots of different usages for automatic compositions!
- Type of approach depends on the goal
  - Do you want an interactive system for a composer?
    - Example: IRCAM@Paris
  - Do you want a fully-automated version (like for videos or games)?
    - Examples: Jukedeck, Melodrove
  - Do you want to accompany someone (e.g. Solo instrument)

Exam

- Material: lectures and papers discussed in the class room
- Mixture of open questions and specific questions
  - E.g. "choose a specific musical feature and describe what information is extracted from a musical document with this feature for what purpose" (though the exam questions will be more specific than this example)
- Symbolic vs. Audio: differences? what can be achieved in what domain?
- Typical challenges, errors and ways of evaluation for a specific computational task (e.g. Corpus analysis, chord recognition)
- Application of your knowledge

Exam

- Find document “Exam_Examplequestions” in Google drive, with example questions

Example questions

- **Example question:** *Basic representation of musical content in digitized music files*
  - a. Please name and give a 1-phrase description of the two different basic representations of digitized musical content.
  - b. For each representation describe one context in sound and music technology in which it is usually employed. Briefly describe one concrete application scenario for each.

Example questions

- **Example question 2**: *Computational modeling of music similarity*
- In the context of music classification in Music Information Retrieval (MIR), the computational modeling of *music similarity* plays a crucial role.
  - a. Name three different types of similarity information extracted from digitized music files in MIR for computing similarity between musical pieces. Give a short description on how this information is used for computing similarity (2 sentences per type of information).
  - b. Name and briefly describe 2 different challenges of modeling similarity in music.
  - c. Choose one accepted method for computing similarity named in 2 a) and describe the steps involved. Typically we expect 4-6 different steps.

Exam

- Find document “Answers_Examplequestions” in Google drive, with example answers

Next lecture

- Michiel Kamp: Department of musicology
- Games: how is music composed to achieve what effects?