Music Generation

Definition, Applications and Ancient techniques

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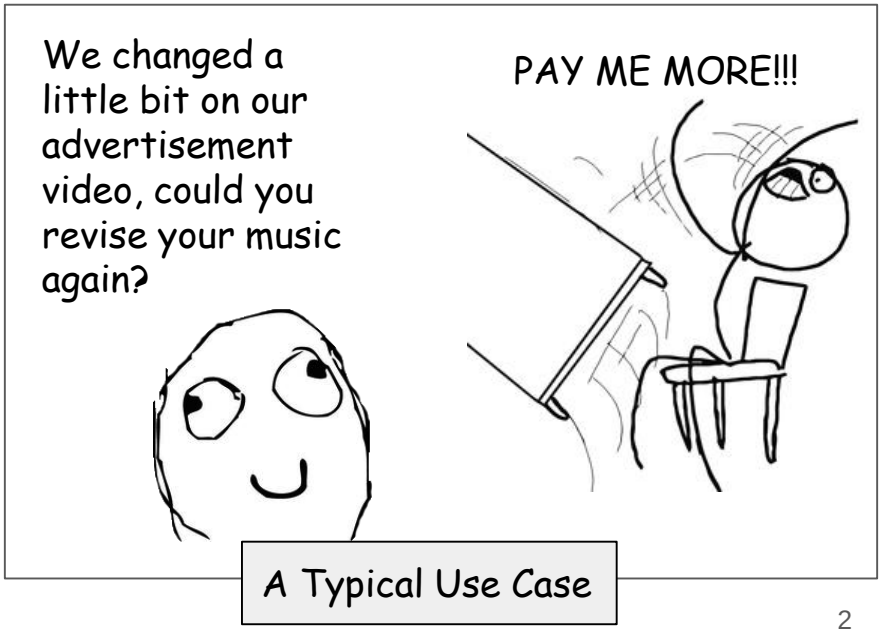
Algorithmic Composition?

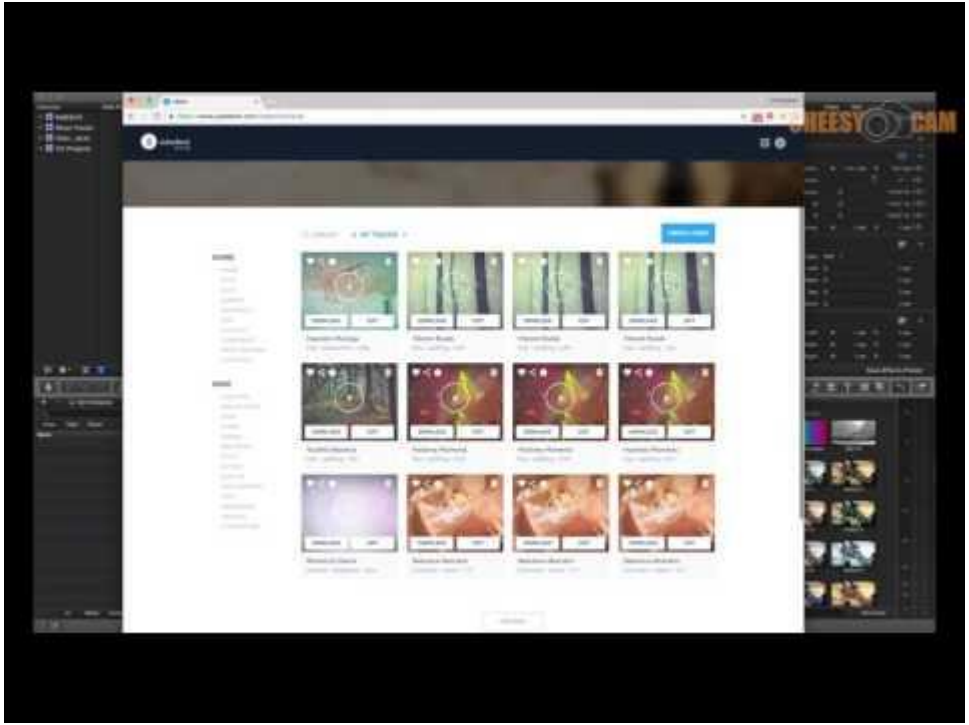
- **Definition**: Algorithmic composition is the partial or total automation of the process of music composition. [Fernandez, Jose D,et al. 2013]

- **Applications**:
  - Generate Music for games/videos
  - Computer aided composition
  - Automatic arrangement
  - Sonification
  - Artificial music friend that accompanies you!
  - And more….

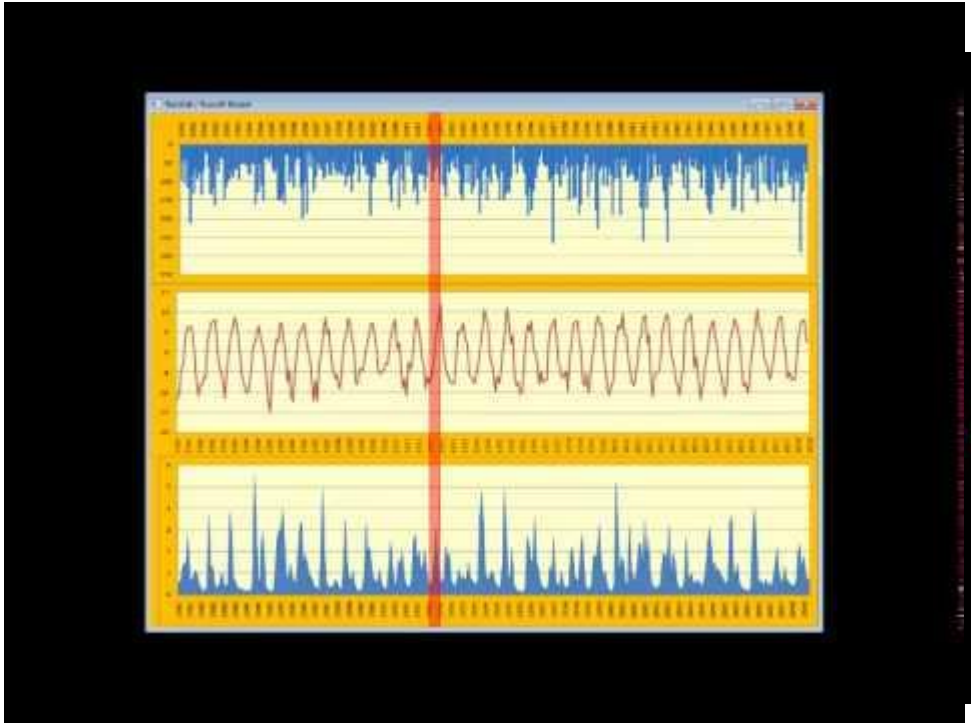


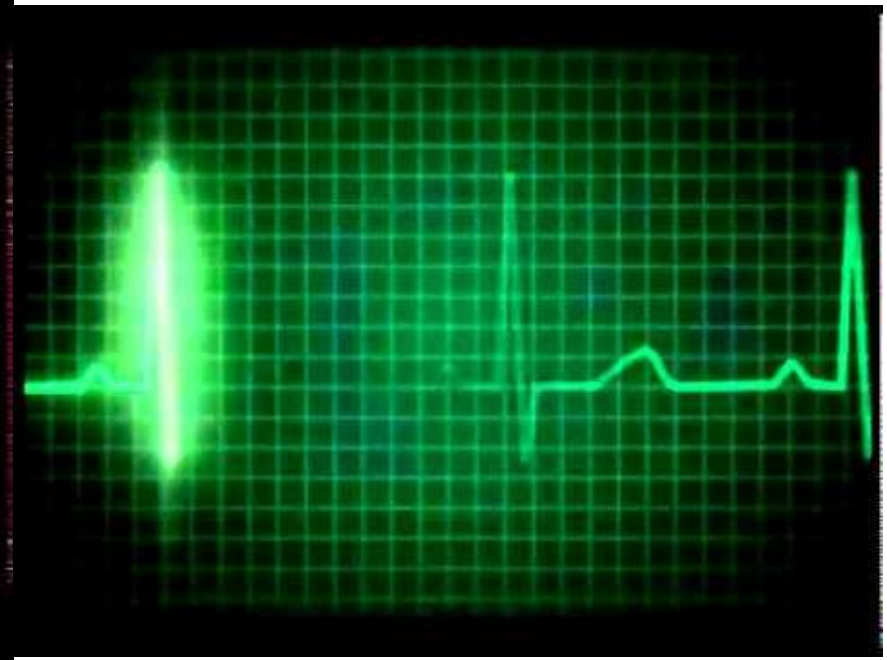
Example: procedural music in No Man’s Sky

Example: creating music content for video



Example: sonification





Example: happy music friends!

Let’s go back to music

Music is so diverse

武満 徹 Toru Takemitsu - Vocalism AI
(~~Artificial Intelligence~~)

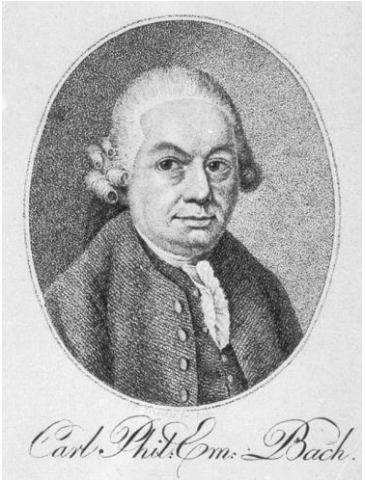
What is music?

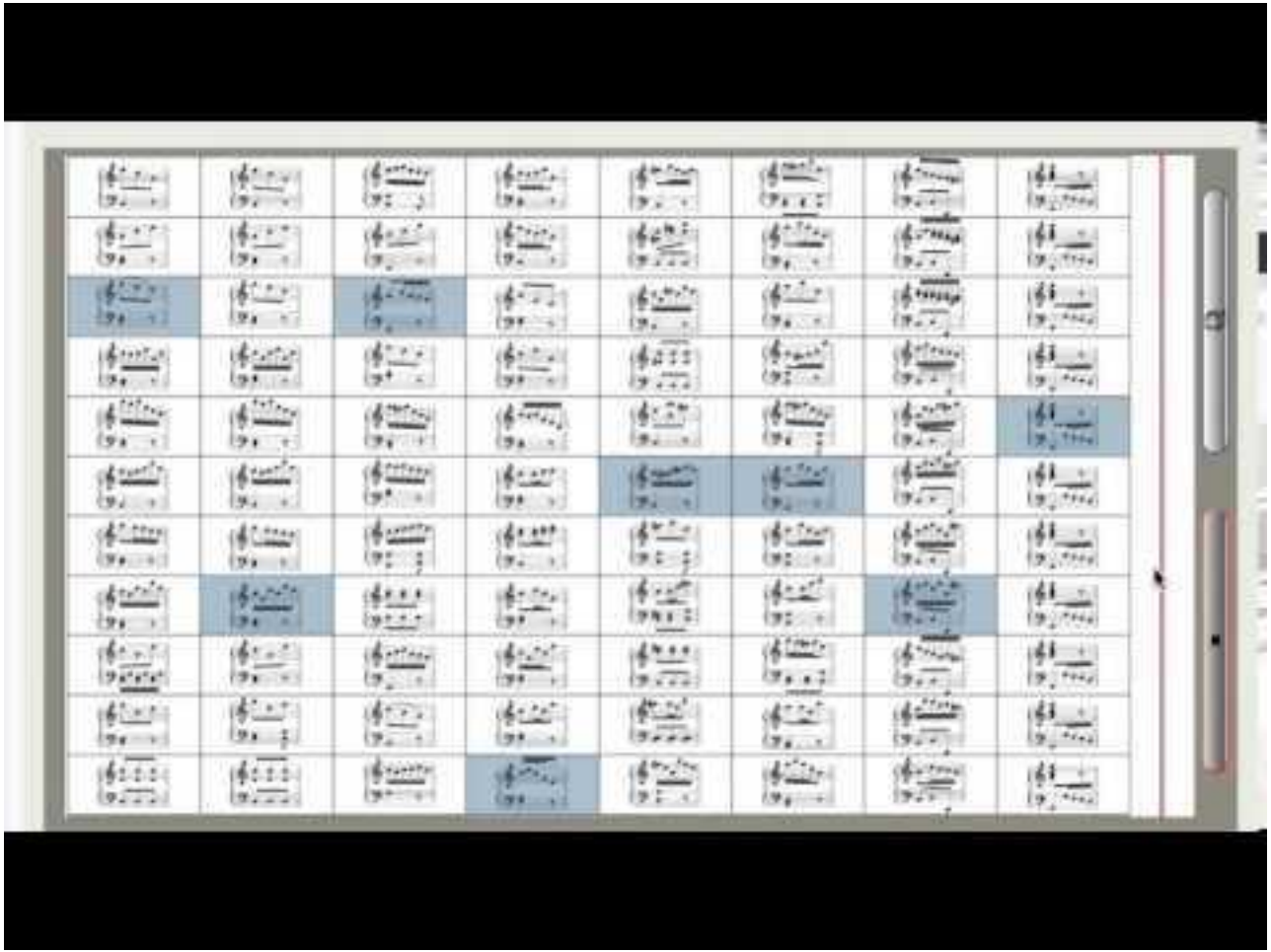
1. Music is organized sound.
2. But not every organized sound is music
3. Still hard to define
4. Engineers and composers may not talk about the same thing.

Musical Dice Game

- Roll a dice to generate music according to some rules
- Mozart’s version: a dice to select segments to play next.
- C.P.E Bach. "A method for making six bars of double counterpoint at the octave without knowing the rules" (1758)
- Maximilian Stadler "A table for composing minuets and trios to infinity, by playing with two dices" (1780)

You can still publish papers in 21st century with these titles.





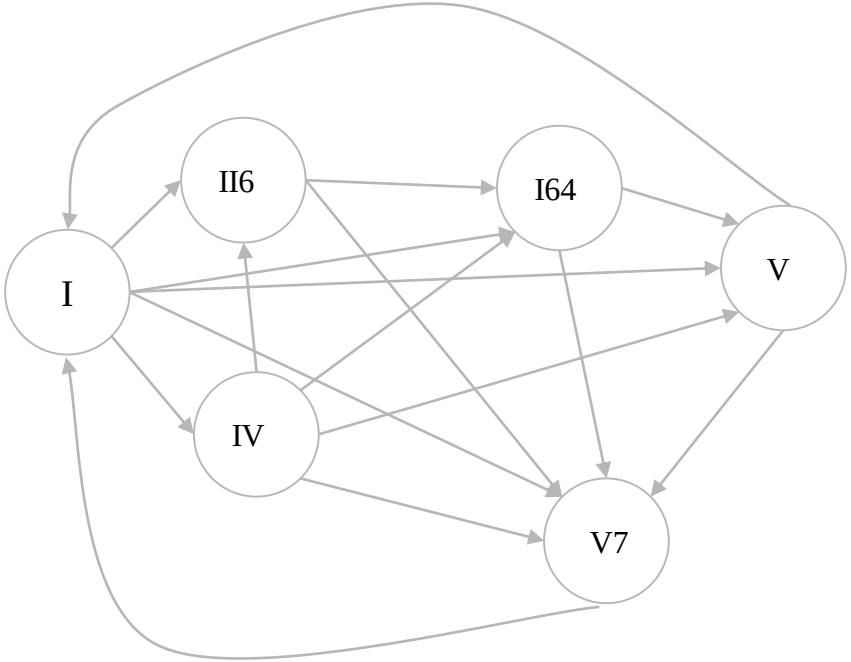
Statistician's Dice: Markov Chain

- The Markov property:
  $p(x_t|all\ past\ values\ of\ x) = p(x_t|ctx_t)$
  $where\ ctx_t = \{x_{t-1} \dots x_{t-k}\}\ is\ a\ finite\ context\ window$
- A finite history window determines the probability distribution of options. We roll a dice to choose between them.
- Rules can be manually designed or learned from data
- Nowadays, Neural Networks are more popular than a probability table based Markov Chain.

Statistician’s Dice: Markov Chain

Possible Variables:

- Pitches
- Durations
- Intervals
- Chords
- And more!

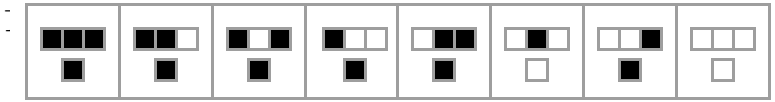


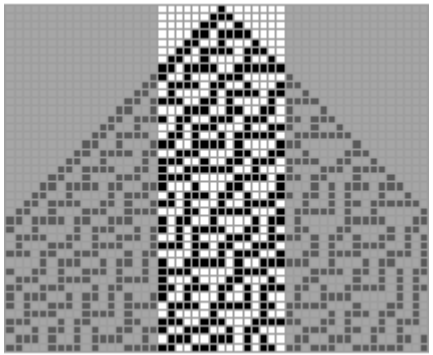
Illiac suite(1957)

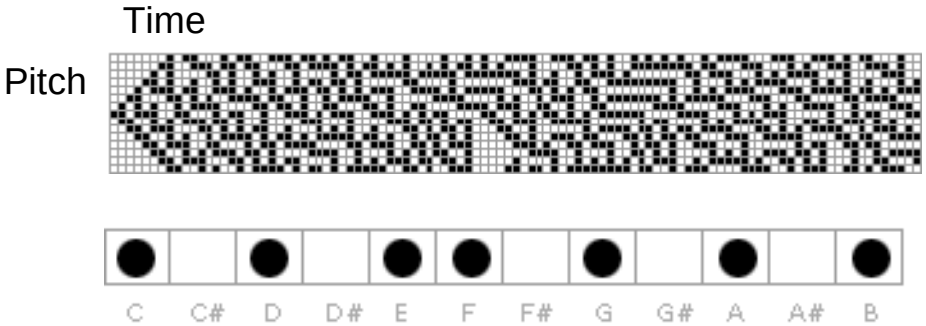
Illiac suite(1957)

Cellular Automata

- Rule based system
- Change the value of each cell according to the local pattern it





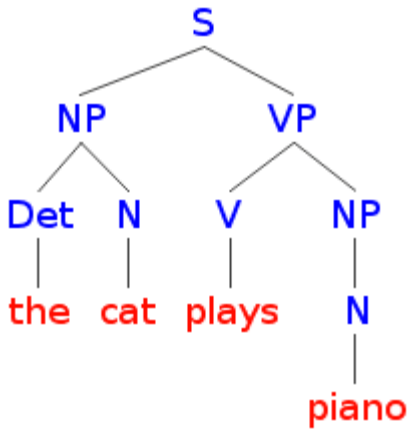


From:[How it works - wolfram alpha tone]

Of course, other dynamic systems can be used

The Grammar of Music

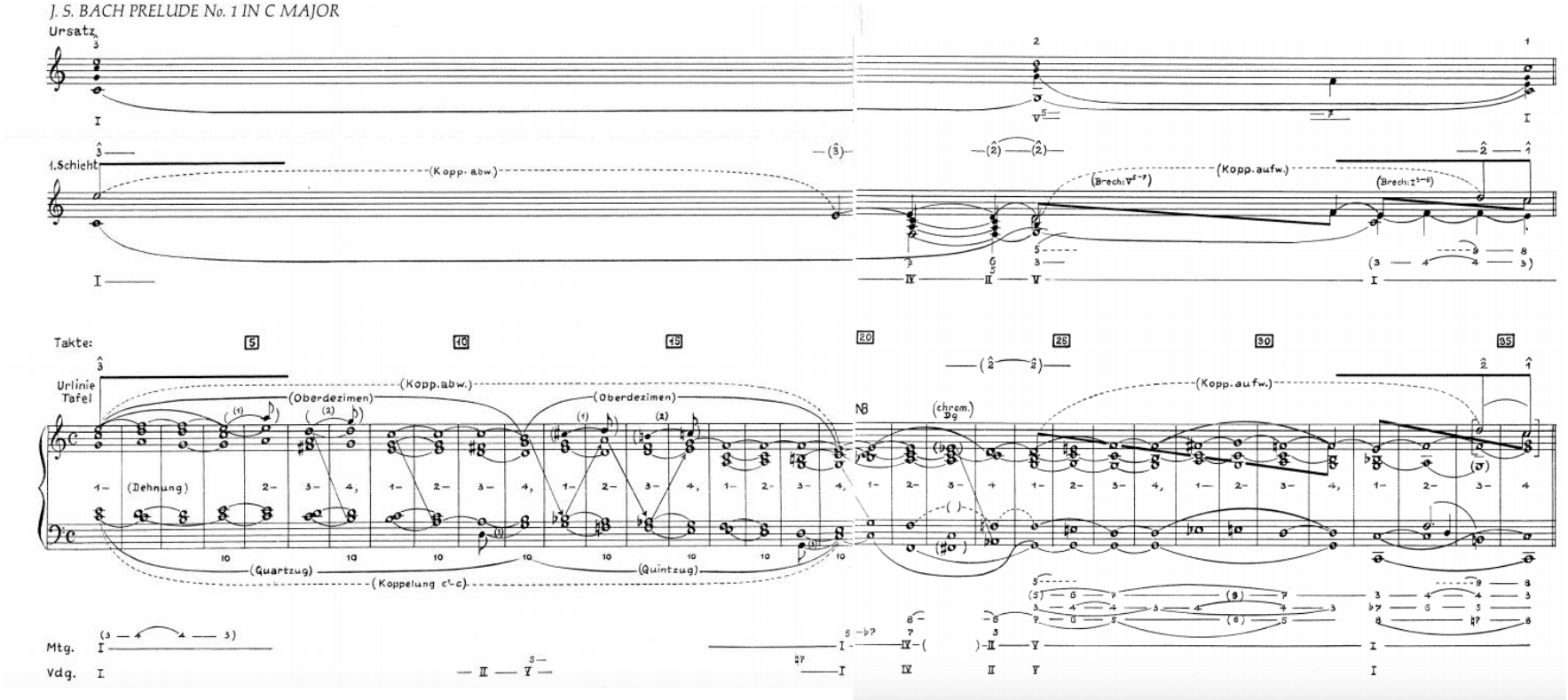
- Grammars are suited to represent system with hierarchical structure.
- What's the evidence of this for music? → Schenkerian Analysis



From: http://allthingslinguistic.com/post/100617668093/how-to-draw-syntax-trees-part-3-type-1-a

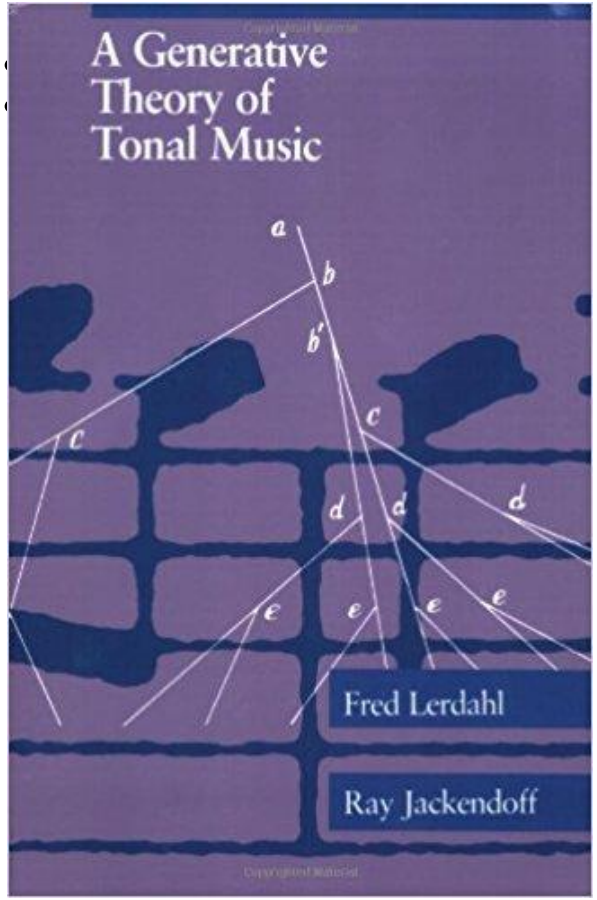
The Grammar of Music- Schenkerian Analysis

a. Schenkerian Analysis is a methodology of music analysis of tonal music.
b. It shows hierarchical relationships among notes, and draws conclusions about the structure of the passage from this hierarchy(foreground, midground and background).
c. Schenkerian Analysis believes that a music piece is generated by some rules of “elaboration” from a simple “fundamental structure”(Ursatz).
d. However, not algorithmic enough.

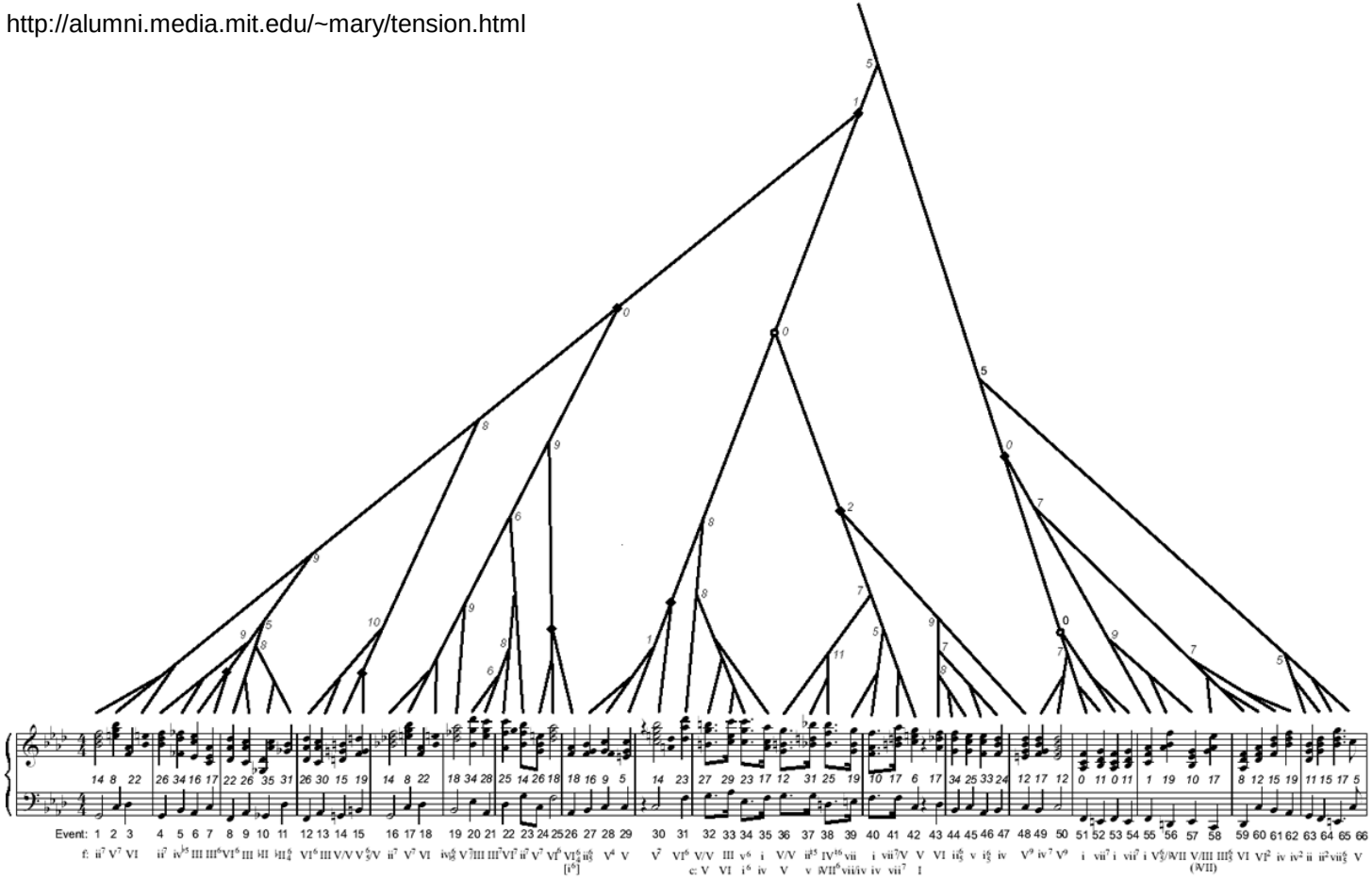

J. S. BACH PRELUDE No. 1 IN C MAJOR
Ursatz
1.Schicht
(Kopp. abw.)
(Kopp. aufw.)
Takte:
5
10
15
20
25
30
35
Urlinie
Tafel
(Kopp.abw.)
(Oberdezimen)
(Oberdezimen)
(Kopp.aufw.)
(Dehnung)
(chrom.)
(Quartzug)
(Quintzug)
(Koppelung c¹-c)
Mtg.
Vdg.

The Grammar of Music

- Generative Theory of Tonal Music
- More detailed rules to construct a tree structure
- Published by American composer and music theorist Fred Lerdahl and American linguist Ray Jackendoff
- Inspired by Noam Chomsky's Generative Grammar
- Still, not algorithmic enough



From http://alumni.media.mit.edu/~mary/tension.html



The Grammar of Music - CFG

How to apply the grammar to generate music?

- Context-Free Grammar
  - Rewriting Rules:
    - A → BC
  - Rewrite one symbol according to a set of rules
  - Example harmony CFG
    - I-> I V I
    - V -> II6 V
    - V -> I64 V
    - II6 -> N6
  - Example Derivation From a Simple CFG:
    - I → I V I → I II6 V I → I II6 I64 V I -> I N6 I64 V I

The Grammar of Music-CFG

Problem:

- Context free grammar still fails to produce some long range dependencies in music
- Rules are hard to design or learn from data

Constraint Satisfaction/Optimization

- Automatic composition as a constraint satisfaction/optimization problem
- Rules are usually manually Designed, for examples:
  - Making variations on existing composition or motif, [13,14,29];
  - Making compositions similar to reference one, [10,22];
  - Making solos or improvised melodies over or by existing templates (proposed rhythm and schedule of chords), [13,14,25];
  - Considering both melody and rhythm: concurrently, [1,14,20], or separately, [28];
  - Considering only melody composition without rhythm [15,29], or only rhythm generation without melody [5,12,31];

From:Matić, Dragan. "A genetic algorithm for composing music." *Yugoslav Journal of Operations Research* 20.1 (2010): 157-177.

Constraint Satisfaction/Optimization

- Usually Genetic algorithm/Simulated Annealing are used for finding a solution that satisfy the constraint or maximizing the predefined goodness
- Very hard to design an optimization objective

Constraint based system: a simple example

What makes music sound good by Dmitri Tymoczko:

https://dmitri.mycpanel.princeton.edu/whatmakesmusicsoundgood.html

Algorithmic Composition as Recombination

- David Cope’s Experiments in Musical Intelligence
- Extract patterns that appear more than once in one composer’s works→ signatures
- Recombine them by pattern Matching to generate new pieces

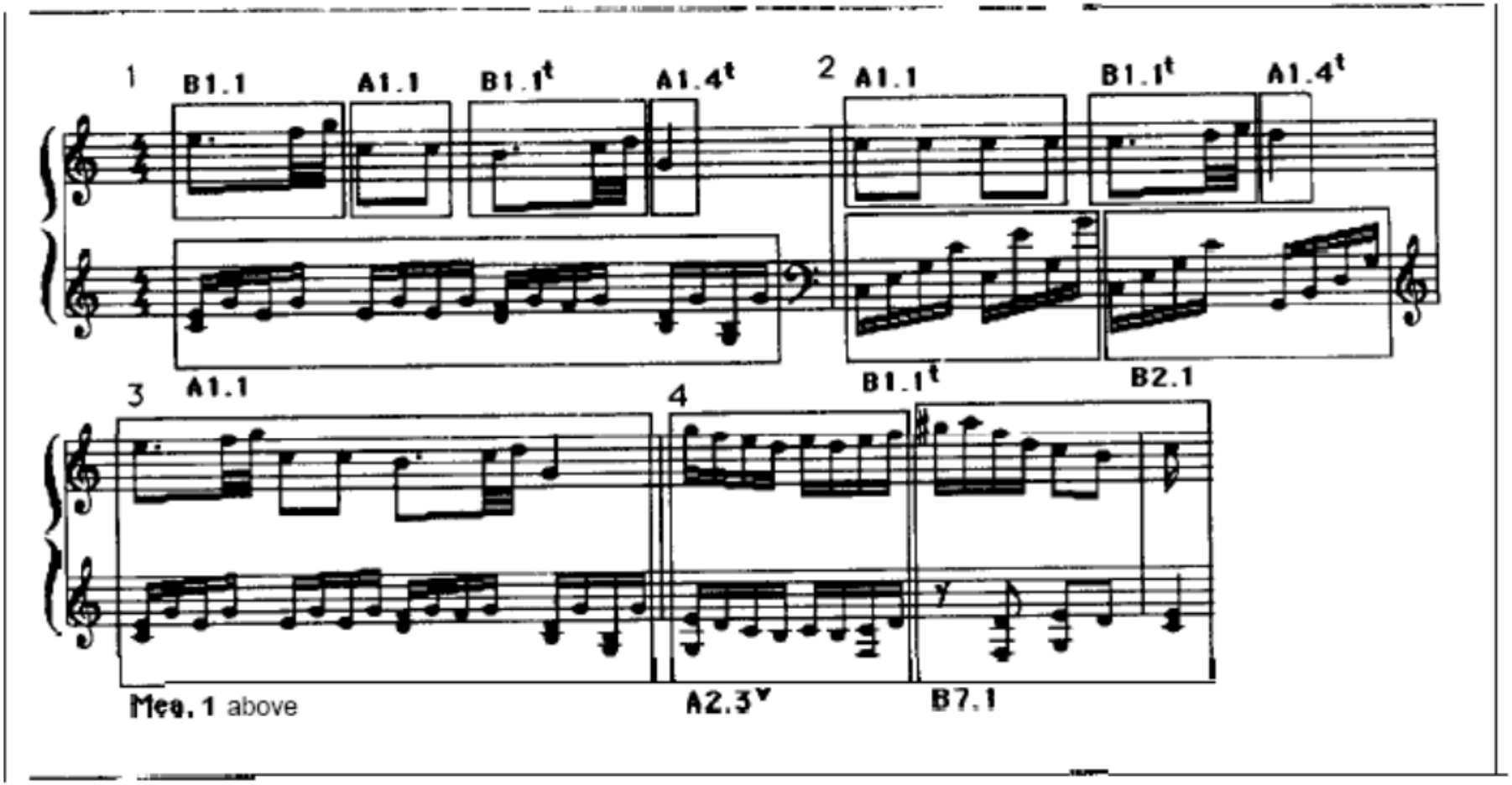


Figure 6. EMI's recombination of segments in Figure 5, with signature (87.1) and suggested sources (t = transposition; v = variation).