Musical Creativity

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Basic Terminology

- Melody = linear succession of musical tones that the listener perceives as a single entity
- Rhythm = "movement" marked by the regulated succession of strong and weak elements, or of opposite or different conditions
- Harmony = use of simultaneous pitches (tones, notes), or chords
- Timbre = is the quality of a musical note or sound or tone that distinguishes different types of sound production
- Tempo = the speed or pace of a given piece
- Dynamics = the softness or loudness of a given note

Music and Automatization

- Strong connections between mathematics and music
- Many music composition tasks can be formalized (e.g. counterpoint)
- Very little real world semantics
- Ideal art form to be automatized?
- The most studied art form with computational means

Computer-Aided Algorithmic Composition (CAAC)

- Very active area of research and commercial software development
  - SuperCollider
  - Csound
  - MAX/MSP
  - Kyma
  - Nyquist
  - AC Toolbox

Algorithmic Sound Synthesis

- Tools for specifying and synthesizing sound waveforms
- Rather than the more abstract specification of music associated with traditional staff notation.
- Line between algorithmic composition and algorithmic sound synthesis is blurred in most of the CAAC systems
- The focus of this lecture is however on algorithmic composition, not on sound synthesis or CAAC tools

Algorithmic Composition and Computational Creativity

- Algorithmic composition means music composition with higher degrees of automation of compositional activities
  - Composition of music with minimal or no human intervention (autonomy)
- Computationally creative music composition systems should also include adaptation and produce more than mere pastiches
- Some of the systems are also intended to model aspects of human music perception and cognitive processes in general

Computer-Aided vs Automatic

- No clear distinction
  - Any automatic generation method can be used as a tool to aid humans
  - Autonomous systems can be built upon existing tools for CAAC

Historical Predecessors in Automated Composition

- Mozart's dice games (Musikalisches Würfelspiel)
- Schoenberg's twelve-tone technique
- Cage's aleatoric music
- ...

- Later: partial or total automation of music composition by formal, computational means (algorithmic composition)

Automatic Music Composition

- The first record: *Illiac Suite* for a string quartet (Hiller and Isaacson, 1958)
  - Rule systems and Markov chains
  - Generated in 1956
  - Series of experiments in formal music composition
  - Musically not very sophisticated or successful
  - However, impressive for its time

Illiac Suite (Excerpt)

Overview of Different Methods

- Grammars
- Knowledge-based systems
- Constraint programming
- Stochastic methods
- Evolutionary algorithms

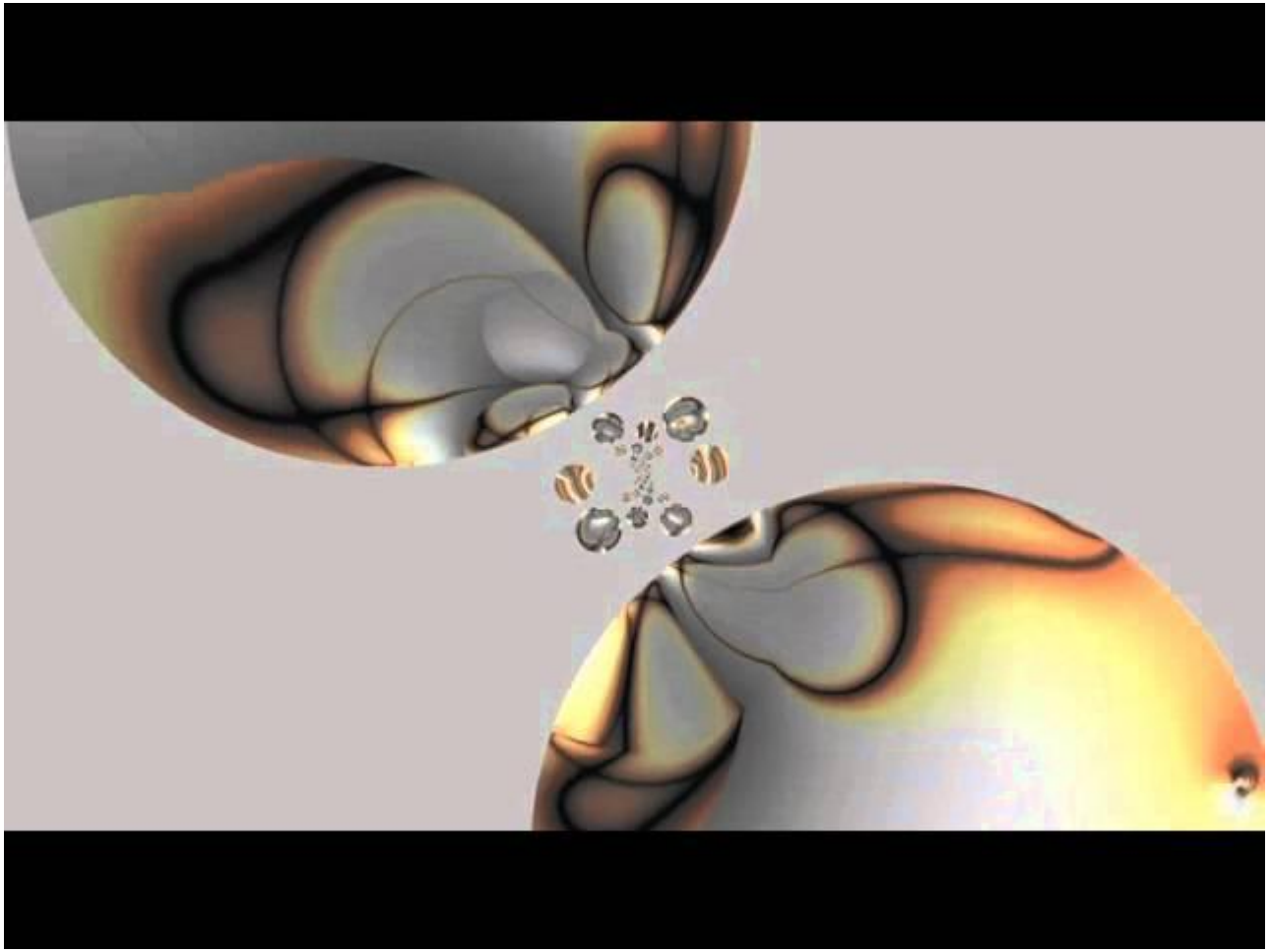
Grammars

- Hierarchical structure by recursive application of rules defined in the grammar
- Early authors derived the rules manually
- *A Generative Theory of Tonal Music* (Lerdahl et al., 1983)
- The problem with a grammatical approach to algorithmic composition is the difficulty to manually define a set of grammatical rules to produce good compositions
- Rule learning
  - E.g. Schwanauer (1993)

Experiments in Musical Intelligence (Cope, 1992)

- Not exactly a grammar but a borderline approach
- Analysis of musical compositions in a given style -> Augmented Transition Network (ATN)
- Basically a finite state automaton able to parse relatively complex languages

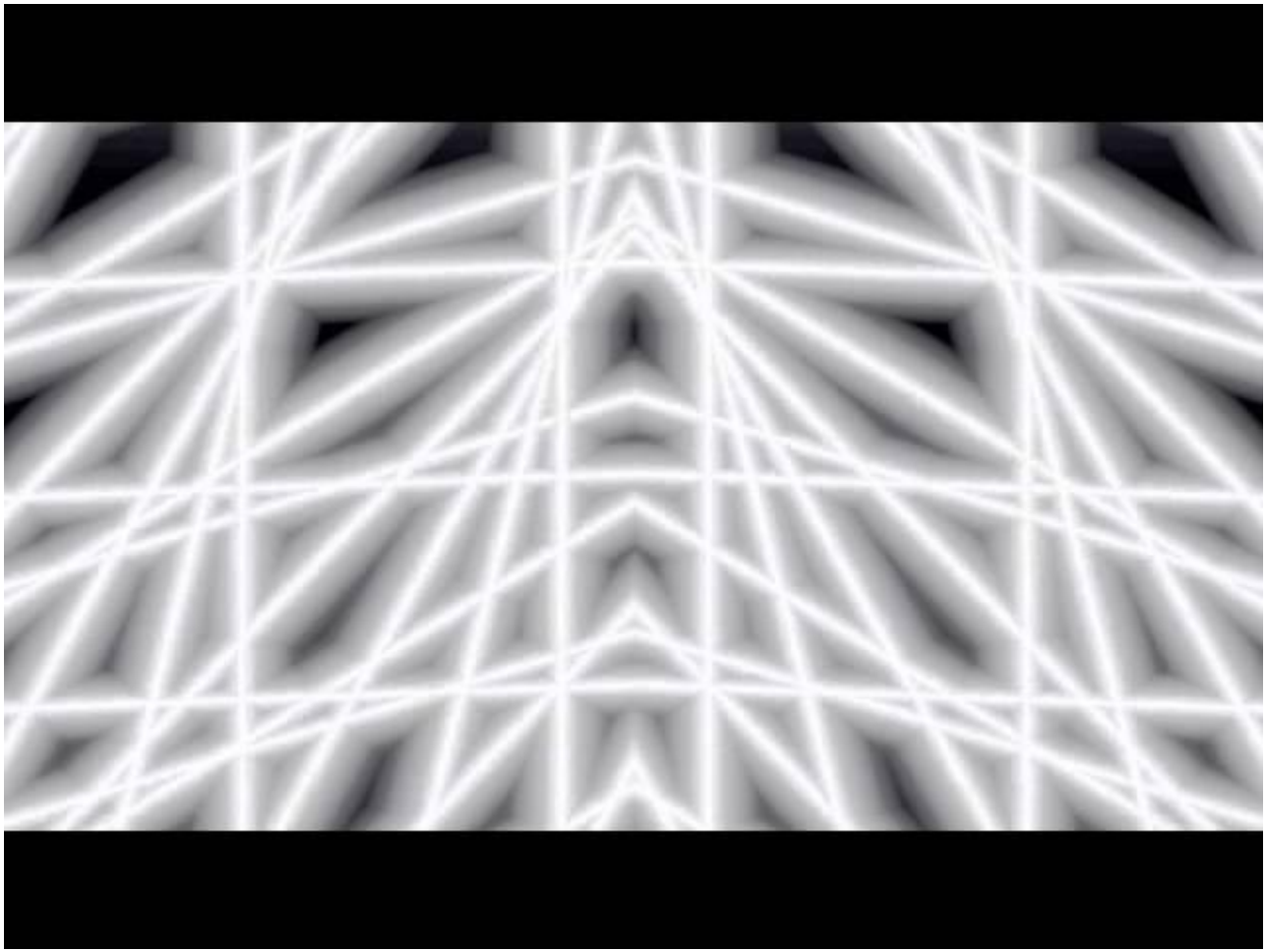
Experiments in Musical Intelligence



Emily Howell (Cope)

- Developed by Cope during the 1990s
- Rule-based system based on the compositions by EMI
- Not very much detailed knowledge about the methodology but very much attention in the popular media

Emily Howell



Constraint Satisfaction

- Describing the problem of music composition as a set of interacting constraints and using existing constraint solvers to search for solutions
- Boenn et al. (2008)
  - Answer set programming to encode rules for melody composition and harmonization
- CHORAL (Ebcioğlu, 1988)
  - Four-part chorales in the style of J.S. Bach
  - Rule-based expert system
  - 350 rules to guide the harmonization process and melody generation

Stochastic Methods

- Markov chains widely used in music
  - Harmony
  - Melody
  - Rhythm
  - Very popular especially in the early years of algorithmic composition
- Problem of having only local constraints
  - No hierarchical structures that are usually present in music at all levels
- Source of raw material, not necessarily for producing the whole composition

IDyOM Model

- Generative model based on the GTTM
- Markov chain of varying length
- Complicated backoff / smoothing
- Training data of approx. 200 choral melodies

Generative Theory of Tonal Music (GTTM)

- “Perfect” theory of tonal music (but still under development)
- Four components: rule sets
- Every component contains hard rules and preference rules
- Because of the preference rules the theory cannot be implemented without modifications
- Thus, more like a descriptive model than an objective model

IDyOM Model

1st-order matrix

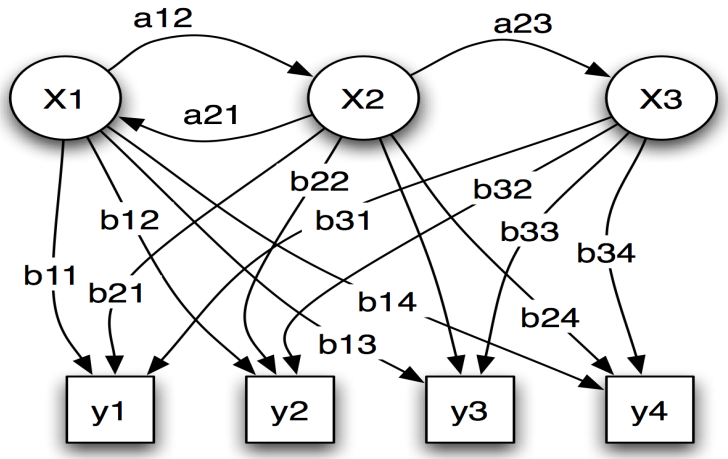
Note	A	C♯	E♭
A	0.1	0.6	0.3
C♯	0.25	0.05	0.7
E♭	0.7	0.3	0

2nd-order matrix

Note	A	D	G
AA	0.18	0.6	0.22
AD	0.5	0.5	0
AG	0.15	0.75	0.1
DD	0	0	1
DA	0.25	0	0.75
DG	0.9	0.1	0
GG	0.4	0.4	0.2
GA	0.5	0.25	0.25
GD	1	0	0

Stochastic Methods

- More sophisticated statistical methods have been applied to different areas of music composition:
  - Hidden Markov Models to harmonize melodies
  - Variable order Markov models to generate chord sequences and melodies



Evolutionary Algorithms

- Repeated cycle of evaluation, selection and reproduction with variation for candidate solutions
- Difficulty of defining automatic fitness functions
- E.g. Marques et al. (2000)
  - Short polyphonic melodies
  - Very direct representation for the genotypes
  - Simple fitness function

Iamus: Example of Evolutionary Music

Where is Creativity?

- Can we call the systems creative?
- How much is there
  - Invention / imagination?
  - Learning and adaptation?
- Is the system able to express something that was not in the training material?
- Could the system surprise its creator?

References

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