Sound and Music Computing Research: Historical References

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"I dream of instruments obedient to my thought and which with their contribution of a whole new world of unsuspected sounds, will lend themselves to the exigencies of my inner rhythm." (Varèse, 1937)

Brief historical outline

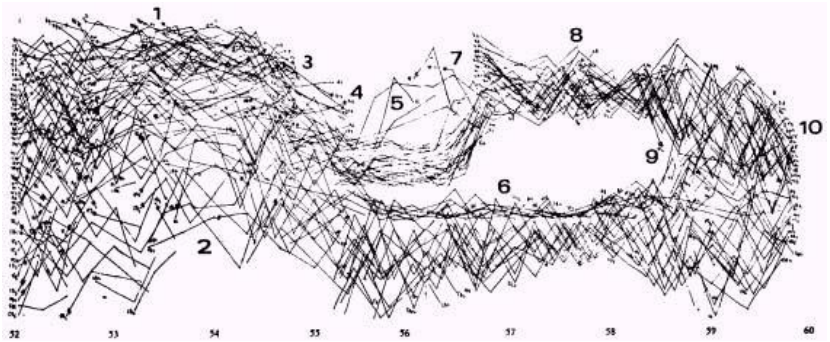
- 1950's-1960's. Algorithmic composition (Hiller, Xenakis, Koenig)
- 1950´s-1960's. Sound synthesis (MUSIC-V)
- 1960's-1970's. Sound Analysis/Synthesis
- 1970's. Music workstations (Chant, 4A)
- 1980's. Physical models, Interactive systems
- 1990's. Music information retrieval

Hiller, L. & L. Isaacson. 1959. *Experimental Music*. McGraw-Hill Book Company, Inc.

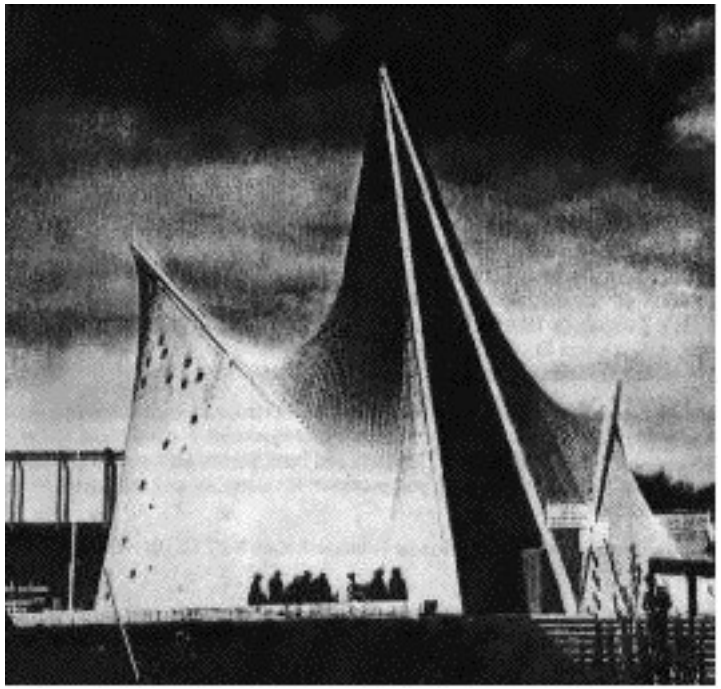
- "The process of composition can be understood as the extraction of order from the chaotic multiplicity of possibilities"
- Information Theory. Method of Monte Carlo. Markov Chain.
- "The Illiac Suite" for String Quartet, 1957
  - Four experiments:
    - Monody, two an four voices
    - Four voices, first spices counterpoint
    - Experimental music
    - Music with Markov chains




Xenakis, Iannis. 1963. *Musiques Formelles*. Revue Musicale.



glissandi in "Pithoprakta"



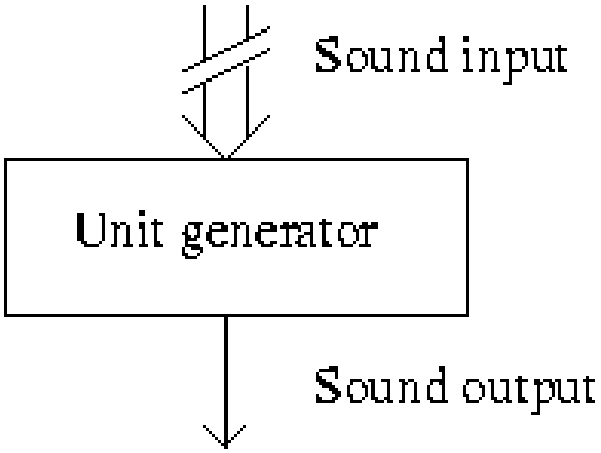
Philips Pavilion on the World Expo 58
in Brussels by LeCorbusier

Mathews, Max. 1969. *The Technology of Computer Music*. MIT Press.

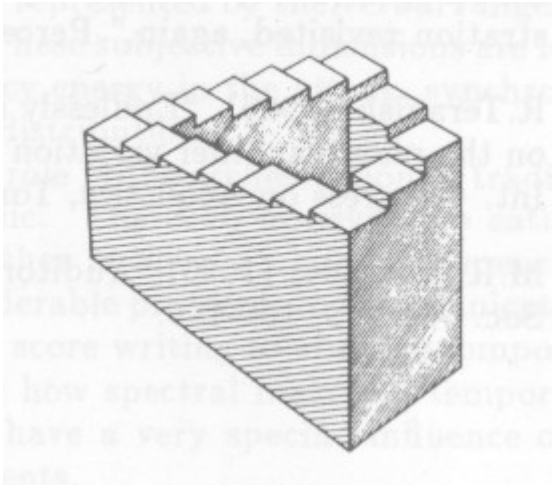
- MUSIC I-II first real computer synthesis program, developed by Max Mathews of Bell Laboratories in 1957.
- MUSIC III in 1960 introduced the concept of a "unit generator".

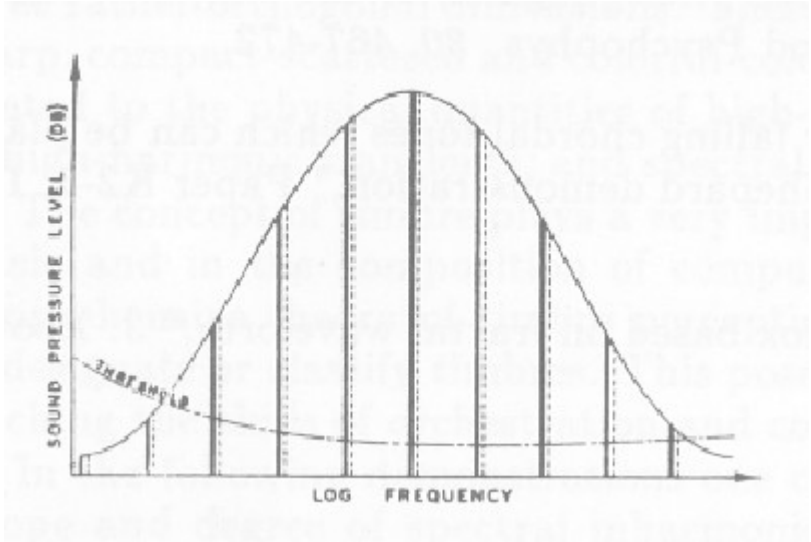
Newman Guttman, 1957:
"The Silver scale"

Daniel Arfib, 1979:
"Le Souffle du Doux"



Risset, J. C. 1969. Pitch Control and Pitch Paradoxes Demonstrated with Computer-synthesized Sounds. *JASA*.





Shepard's original paradox

Risset's adaptation

Matthews, M. & Moore, R. 1970. Groove—A Program to Compose, Store, and Edit Functions of Time. *Communications of the ACM*.

The GROOVE System
at the Bell Telephone Labs ,
c1970

Groove: Generated Real-time Operations On Voltage-controlled Equipment

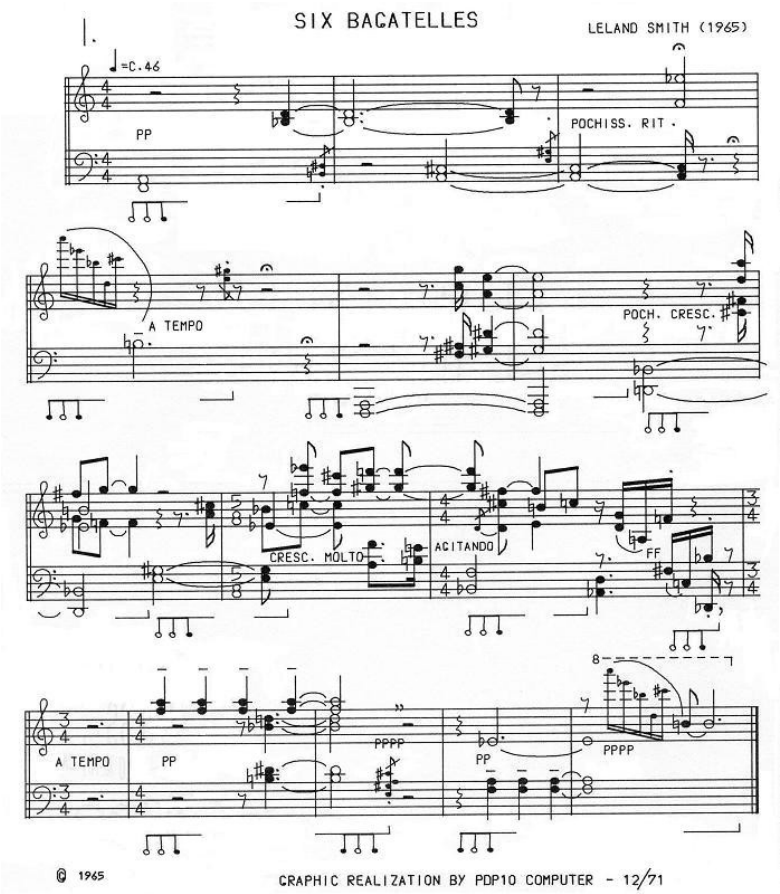
Emmanuel Ghent, 1970:
"Phospones"

Koenig, G. M. 1970. *Project One*. Electronic Music Reports 2. Utrecht: Institute of Sonology.

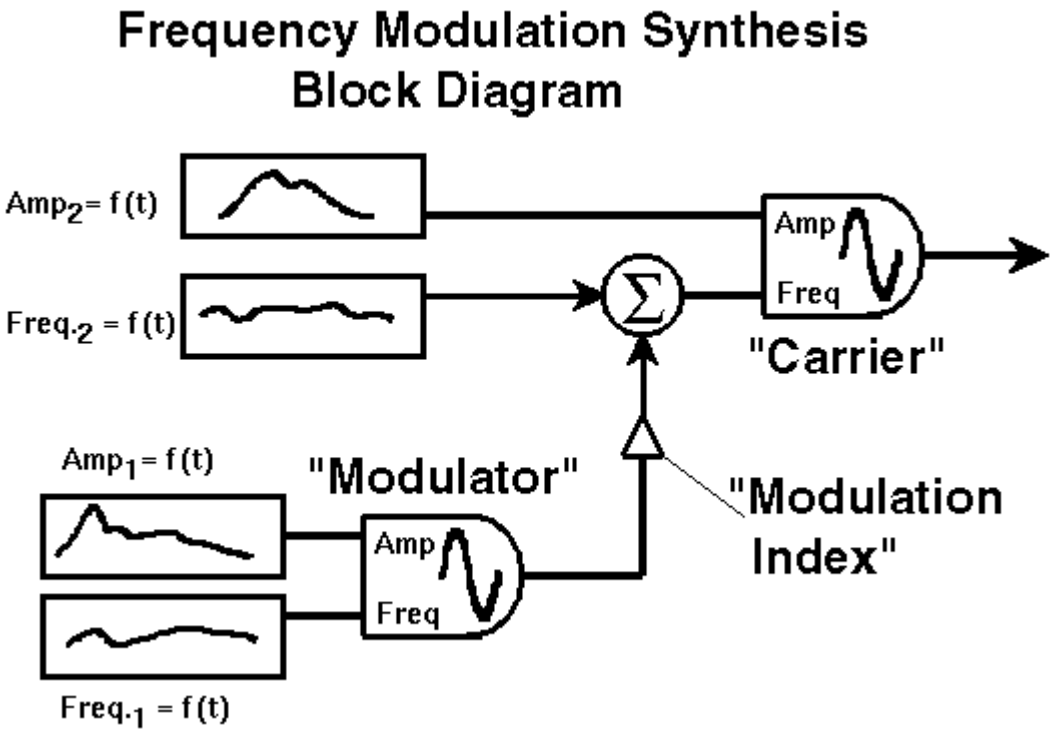
- *Project 1* was born in 1964 of the wish to test the compositional rules of serial music.
- Project 2 (1966) parameters:
  - Instrument: lists of instrument names
  - Rhythm: lists for entry delays, durations, rests and tempi.
  - Harmony: a choice of three harmonic principles: chord list, row, interval table.
  - Dynamics: list of dynamic indications.
  - Articulation: list of articulation modes.

Koenig, 1982: "Three Asko Pieces" 

Smith, L. C. 1972. Score, a musician's approach to computer music. *Journal AES*.



Chowning, J. 1973. The Synthesis of Complex Audio Spectra by Means of Frequency Modulation. *Journal AES*.



FM with vibrato

From a bell to a voice

DX7 Rhodes

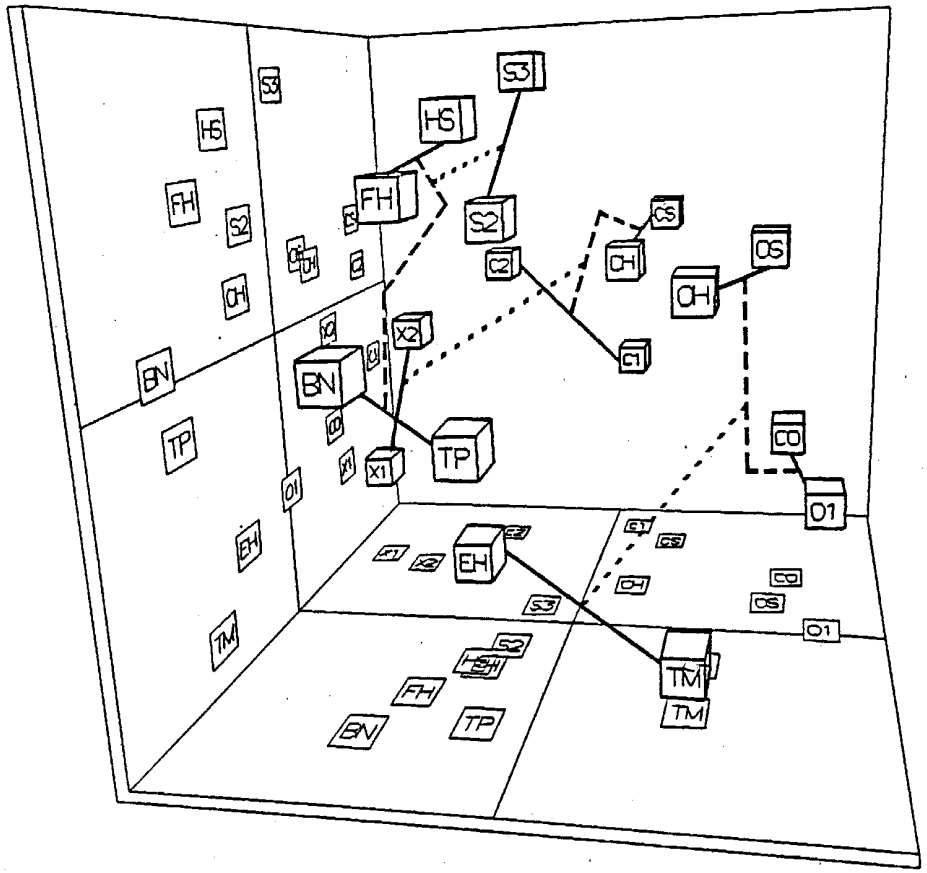
Chowning, 1977: "Turenas"

Moorer, J. A. 1975. *On the Segmentation and Analysis of Continuous Musical Sound by Digital Computer*. Ph.D. thesis, Stanford University.

Reference	Institute	Performance	Knowledge used
Moorer75	Stanford University	Polyphony:2 (severe limitations on content). Sounds: violin, guitar. Note range: 24.	Heuristic approach.
Chafe82, 85,86	Stanford University	Polyphony:2 (presented simulation results insufficient). Sound: piano. Note range: 19.	Heuristic approach.
Maher89, 90	Illinois University	Polyphony: 2. Sounds: clarinet, bassoon, trumpet,tuba, synthesized. Note ranges: severe limitation, pitch ranges must not overlap.	Heuristic approach.
Katayose89	Osaka University	Polyphony:5 (several errors allowed). Sounds: piano, guitar, shamisen. Note r.: 32.	Heuristic approach.
Nunn94	Durham University	Polyphony: up to 8 (several errors allowed, perceptual similarity). Sound: organ. Note range: 48.	Perceptual rules.Architecture: bottom-up abstraction hierarchy.
Kashino93, 95	Tokyo University	Polyphony: 3 (quite reliable). Sounds: flute, piano, trumpet, automatic adaptation to tone. Note range: 18.	Perceptual rules, timbre models, tone memories, statistical chord transition dictionary. Architecture: blackboard, Bayesian probability network
Martin96	MIT	Polyphony: 4 (quite reliable). Sound: piano. Note range: 33.	Perceptual rules. Architecture: blackboard

Klapuri 2001: original  transcription 

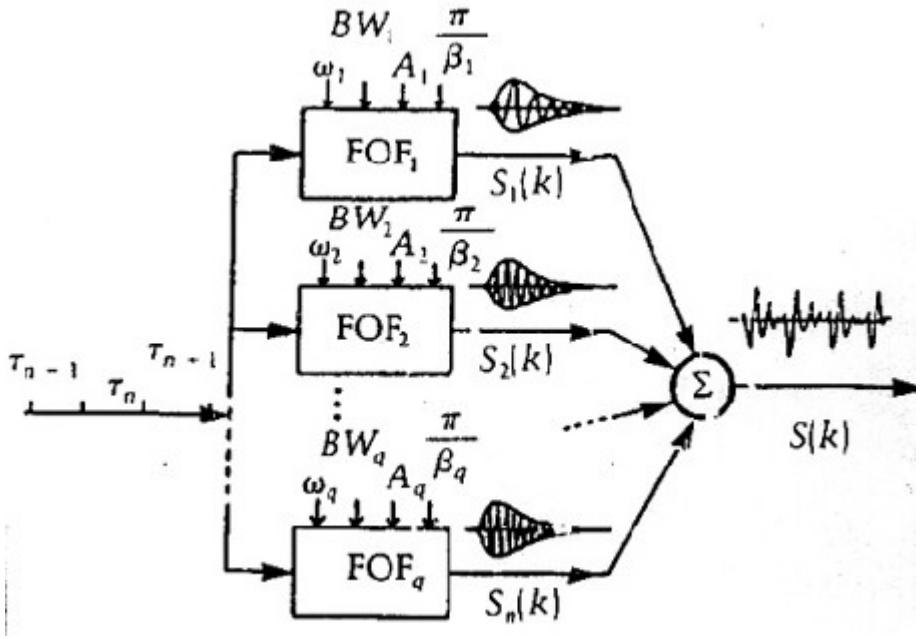
Grey, J. M. 1975. *An Exploration of Musical Timbre*. Ph.D. thesis, Stanford University.



Factors determining the timbre of a musical sound:

- Loudness
- Amplitude envelope
- Fluctuations of pitch and intensity
- Formant structures
- Temporal evolution of spectral distribution

Rodet, Xavier. 1977. *Analyse du Signal Vocal dans sa Representation Amplitude-Temps. Synthese de la Parole par Regles*. These de l'Universite Paris-6.



Aria from the Queen of the Night from the Magic Flute by Mozart

Gesualdo

Barrier, 1983: "Chreode I"

Moorer, J. A. 1978. The use of the phase vocoder in computer music applications. *Journal AES*.

STFT: $$X_l(k) = \sum_{n=0}^{N-1} w(n)\,x(n+lH)\,e^{-j\omega_k n} \qquad l=0,1,\ldots$$

Inverse STFT: $$s(n) = \sum_{l=0}^{L-1} Shift_{lH,n}\left[\frac{1}{K}\sum_{k=0}^{K-1} X_l(k)\,e^{j\omega_k m}\right]$$

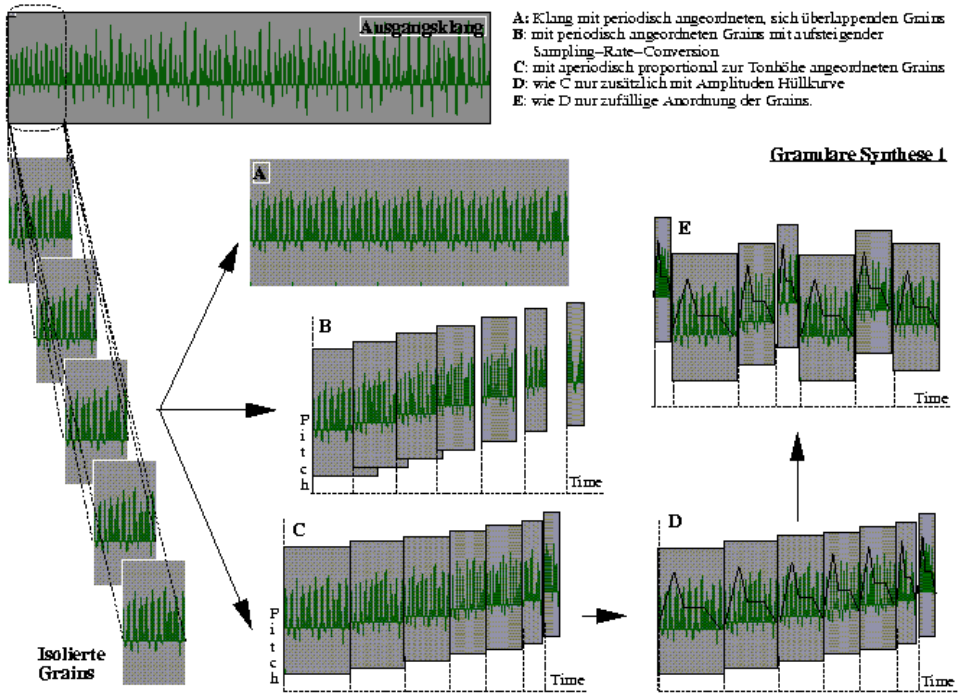
Pitch transposition (by Dolson)


Combined changes (by Dolson)

Time stretch (by Dolson)

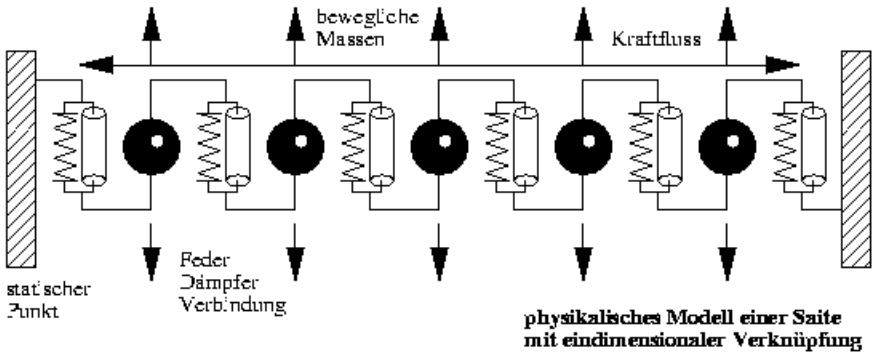

Roads, C. 1978. Granular Synthesis of Sound. *Computer Music Journal.*

"All sound is an integration of grains, of elementary sonic particles, of sonic quanta." -Xenakis (1971).

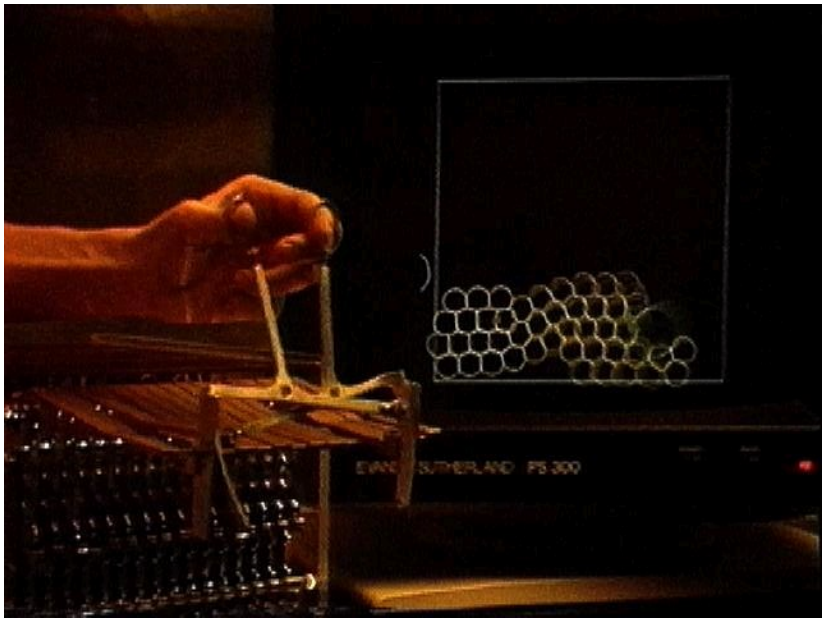


Helmuth's example

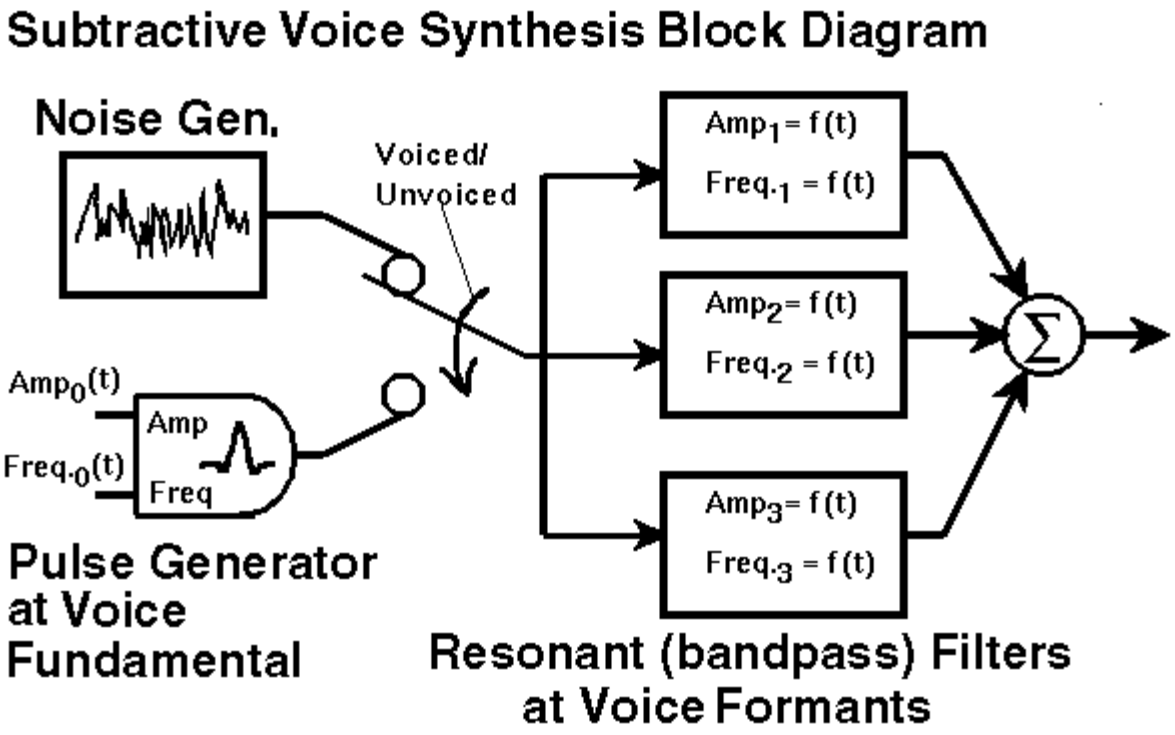
Cadoz, C. 1979. Synthese sonore par simulation des mécanismes vibratoires. Thèse.



physikalisches Modell einer Saite
mit eindimensionaler Verknüpfung

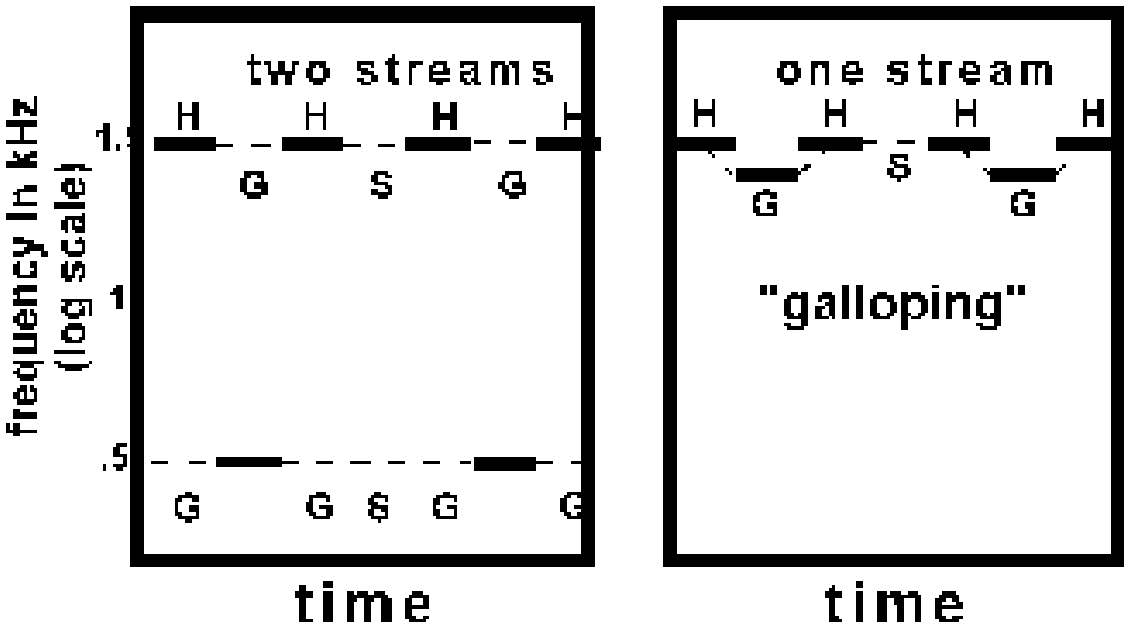


Moorer, J. A. 1979. The use of linear prediction of speech in computer music applications. *J. AES*.



Dodge:
"Any Resemblance
Is Purely Coincidental"

McAdams, S. & A. Bregman. 1979. Hearing Musical Streams. *Computer Music Journal.*

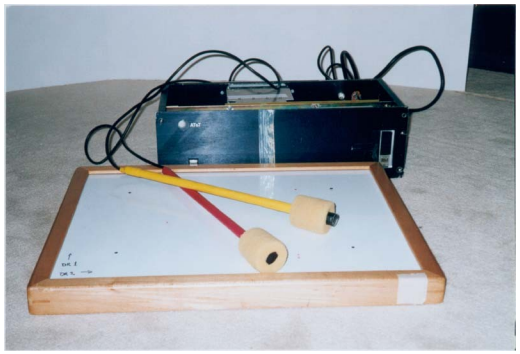


Auditory Scene Analysis examples

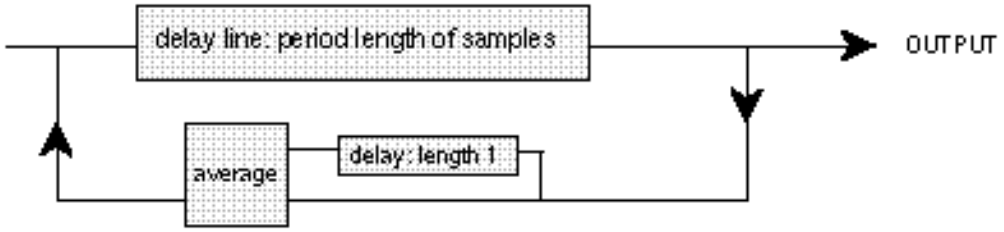
Samson, P. R. 1980. A general-purpose digital synthesizer. *Journal of the AES.*

- 256 generators (waveform oscillators with several modes and controls, complete with amplitude and frequency envelope support)
- 128 modifiers (each of which could be a second-order filter, random-number generator, or amplitude-modulator, among other functions).
- 64 Kwords of delay memory with 32 access ports could be used to construct large wavetables and delay lines. A modifier could be combined with a delay port to construct a high-order comb filter or Schroeder allpass filter--fundamental building blocks of digital reverberators.
- Four digital-to-analog converters.

Matthews, M. and C. Abbott. 1980. The Sequential Drum. *CMJ*.

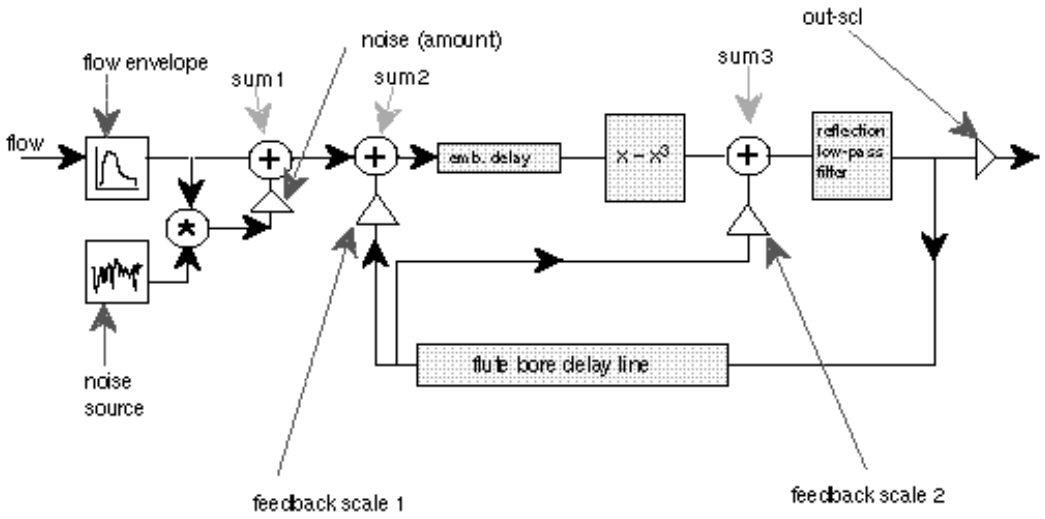


Karplus, K. and Strong, A. 1983. Digital synthesis of plucked-string and drum timbres. *CMJ*.



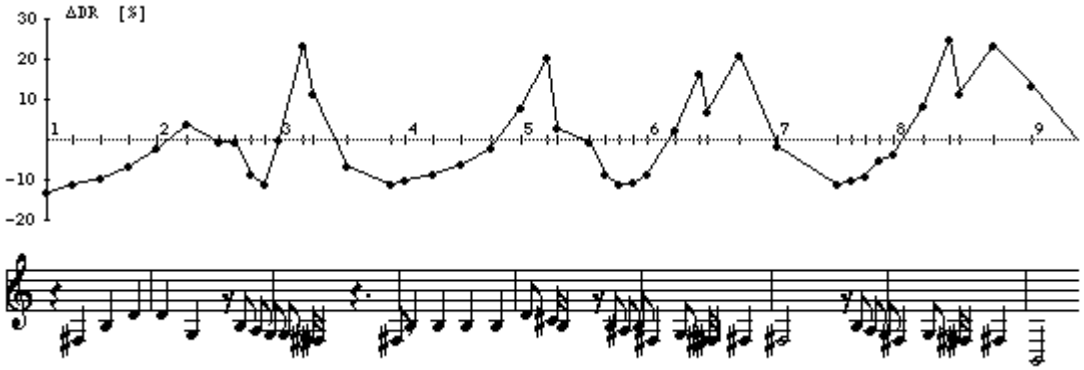
Plucked-string model

Jaffe, 1988:
"Silicon Valley Breakdown"



Physical model of a flute

Sundberg J. et alt. 1983. Musical performance: A synthesis-by-rule approach. *CMJ*.



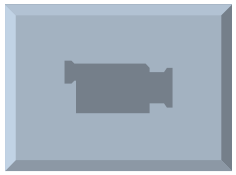
Director Musices:
Phrase arch rule

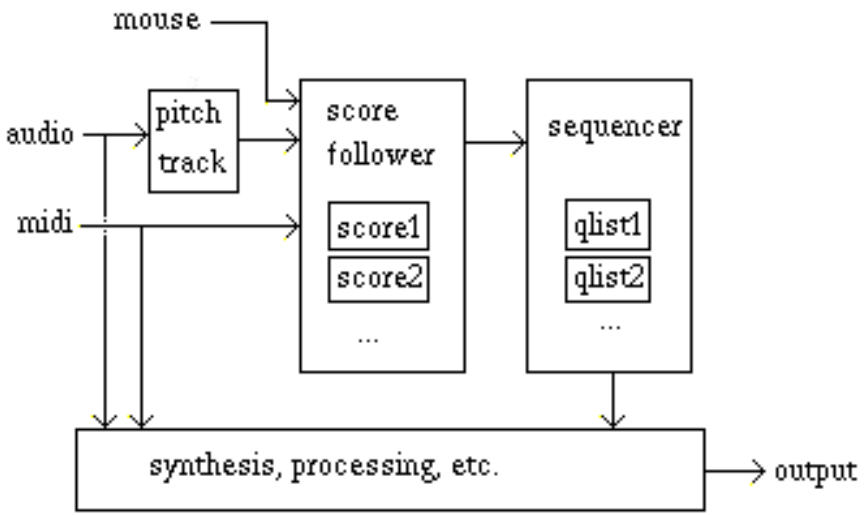
No-phrasing

Medium phrasing

Dannenberg, R. 1984. An On-line Algorithm for Real-Time Accompaniment. *ICMC*.

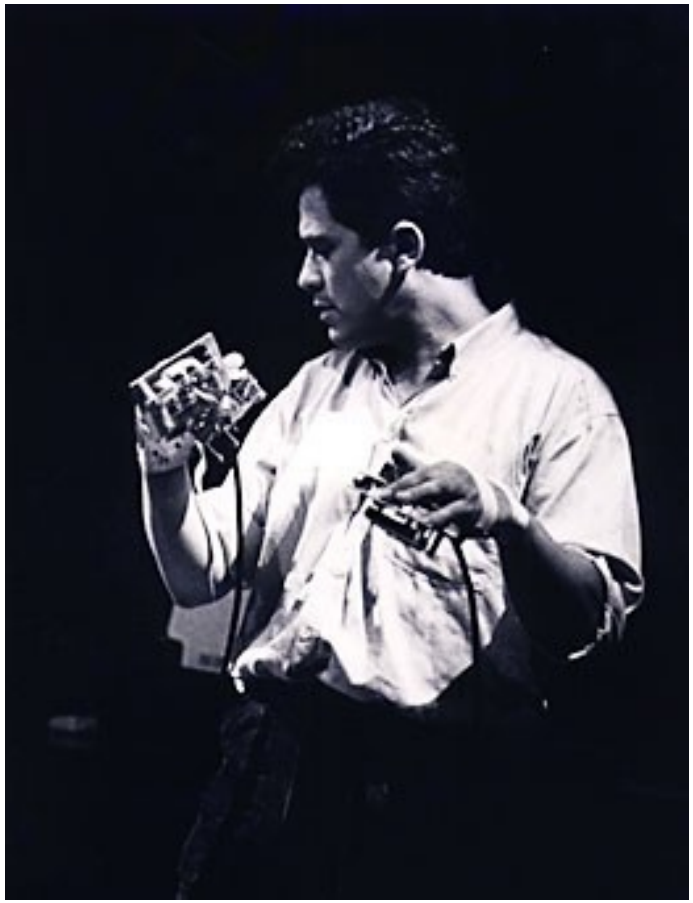
Automatic Accompaniment example





Waiswisz, M. 1985. The HANDS, a Set of Remote MIDI-Controllers. *ICMC*.

The Hands are two aluminum plates containing touch sensitive keys, thumb pressure sensors, and tilt and proximity sensors, held under a performer's hands with velcro fasteners.



Cope, David. 1987. An Expert System for Computer-assisted Composition. *CMJ*.

The EMI system is based on:

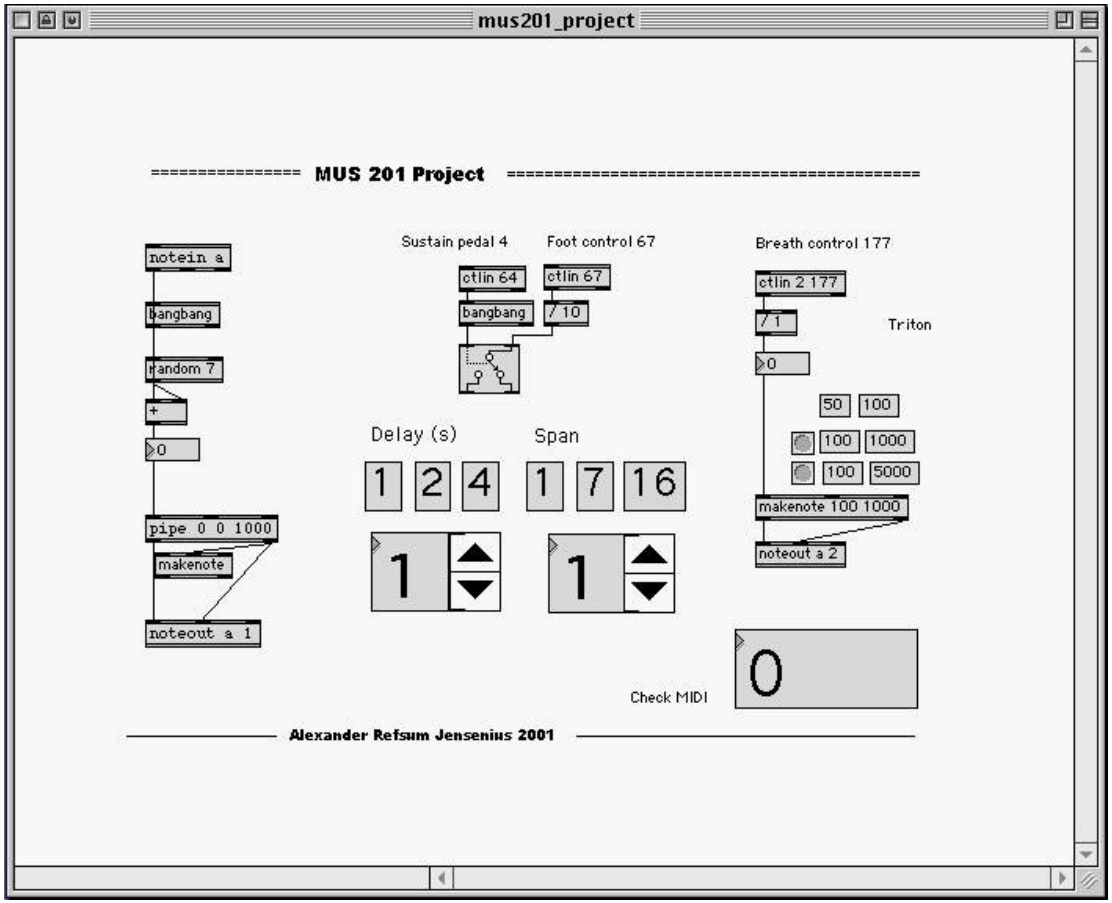
- deconstruction (analyze and separate into parts)
- signatures (commonality - retain that which signifies style)
- compatibility (recombinancy - recombine into new works)

EMI Bach Invention

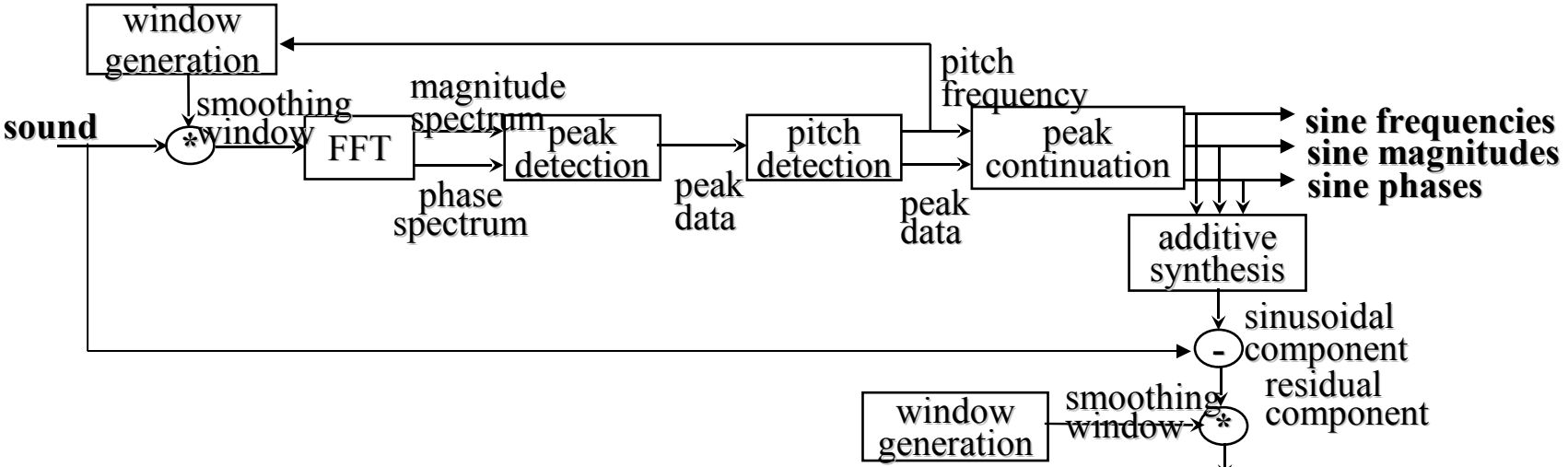
EMI Beethoven sonata

EMI Joplin music

Puckette, M. 1988. The Patcher. *Proceedings of the ICMC.*



Serra, X. 1989. *A System for Sound Analysis / Transformation / Synthesis Based on a Deterministic Plus Stochastic Decomposition*. Thesis, Stanford University.



Original

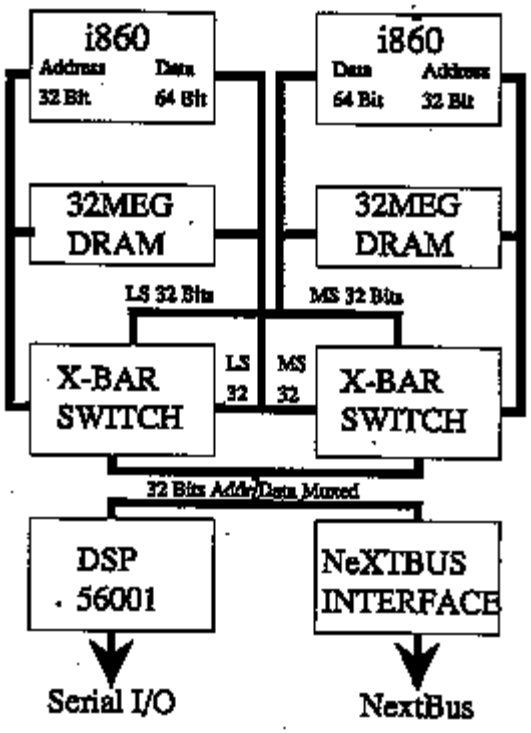
Deterministic

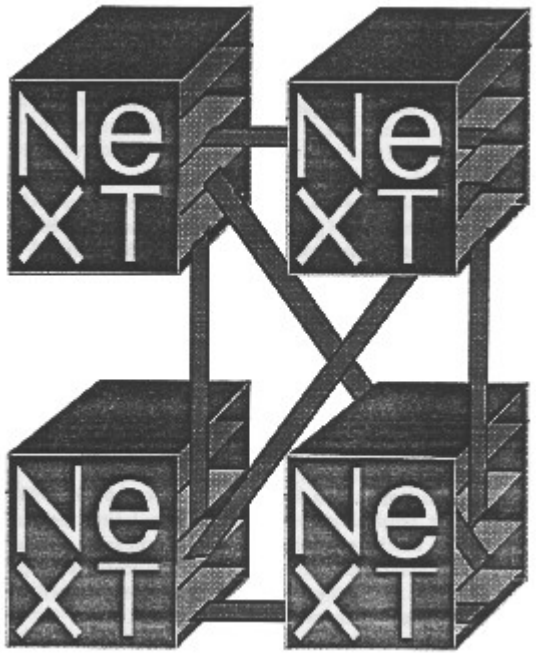
Stochastic

Synthesis

Transformations

Lindemann, E. et alt. 1991. The Architecture of the IRCAM Musical Workstation. *CMJ*.





Feiten, B. & S. Guenzel. 1994. Automatic Indexing of a Sound Data Base using Self-Organizing Neural Nets. *CMJ*.

- Music Information Retrieval