Directions de recherche actuelles en composition assistée par ordinateur

Projet *EFFICAC(e)*
[Extended Framwork for In-time Computer-Aided Composition]

Jean Bresson
UMR STMS - IRCAM

PROJET FINANCÉ PAR L'ANR
ANR
PROJECT FUNDED BY THE ANR

Participants :

- Jean Bresson (IRCAM - Représentations Musicales)
- Diemo Scwartz (IRCAM - Interactions Musicales Temps Réel)
- Thibaut Carpentier (IRCAM - Espaces Acoustiques et Cognitifs)
- Florent Jacquemard (IRCAM - Représentations Musicales/Mutant)
- Dimitri Bouche (PhD, IRCAM - Représentations Musicales)
- John MacCallum (CNMAT / UC Berkeley)
- Rama Gottfried (UC Berkeley)

Thèmes abordés :

- Processus réactifs en CAO
- Structures temporelles dynamiques
- Interaction dans le contrôle de la synthèse et de la spatialisation
- Intégration de données et interfaces gestuelles
- ...

OpenMusic

Computer-Aided Composition environment

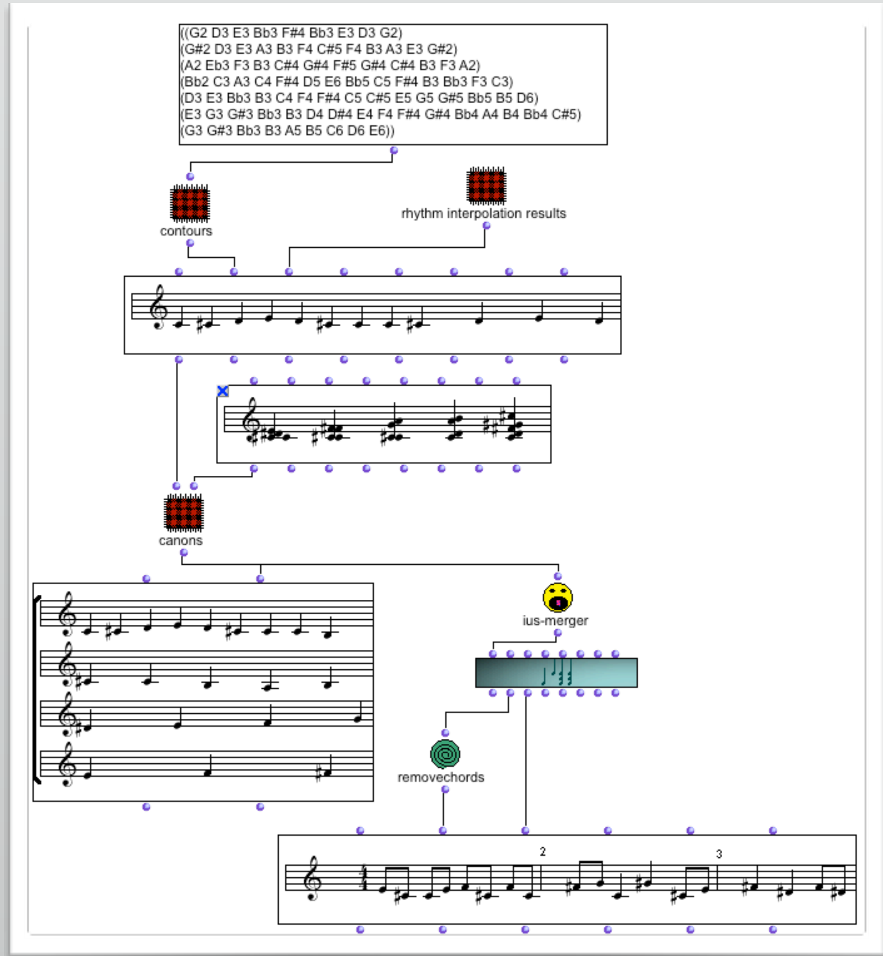
Symbolic computation

Musical data structures

G. Assayag, C. Rueda, M. Laurson, C. Agon, O. Delerue. "Computer Assisted Composition at Ircam: PatchWork & OpenMusic", Computer Music Journal, 23(3), 1999.

Visual programming language

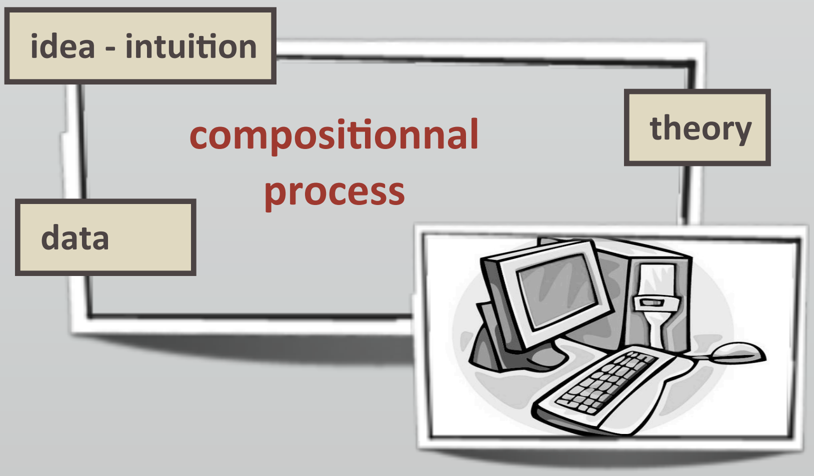
J. Bresson, C. Agon, G. Assayag. "Visual Lisp/CLOS Programming in OpenMusic"
Higher-Order and Symbolic Computation, 22(1), 2009.



http://repmus.ircam.fr/openmusic/

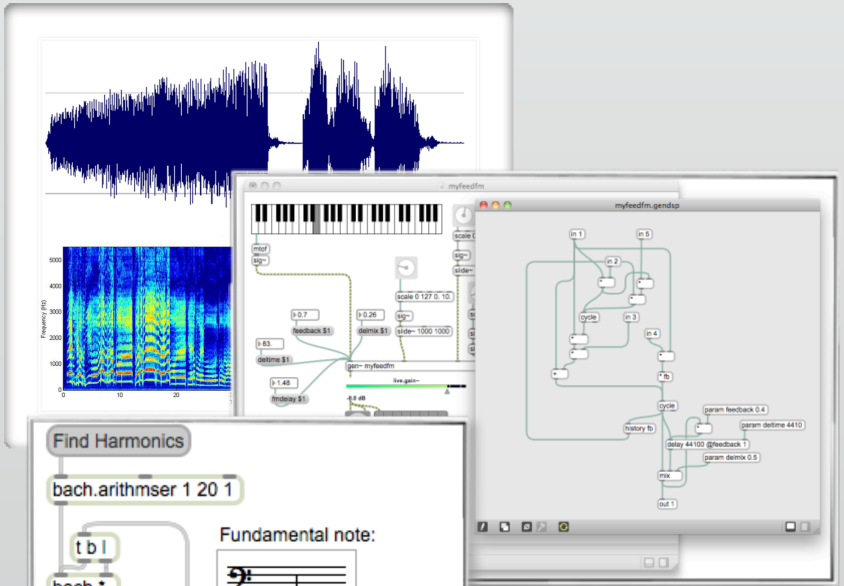
Specificity of the computer-aided composition approach

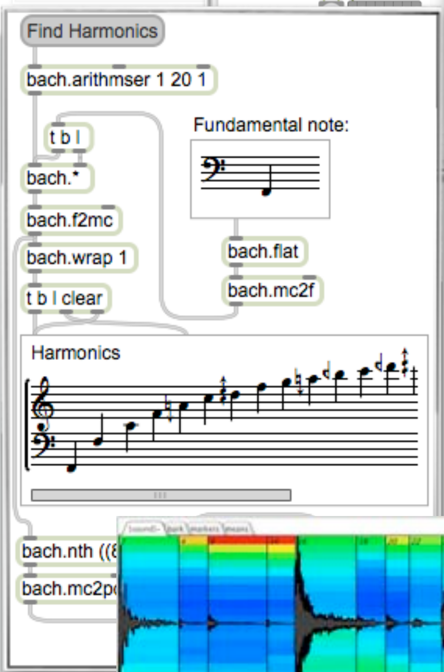
a.k.a. “what is the difference between OM and Max?”

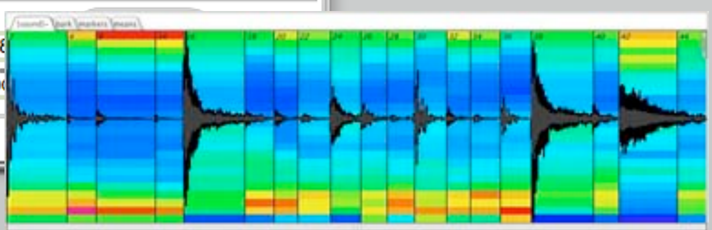


"We conceive such an environment [of computer-aided composition] as a specialized computer language that composers will use to build their own musical universe. [...] This leads us to reflect on the various existing programming models, as well as on the interfaces [...] which make it possible to control this programming, and on the representations of the musical structures, which will be built and transformed using this programming."
G. Assayag, Computer Assisted Composition Today (1998).

Digital signal processing vs. symbolic music processing ?

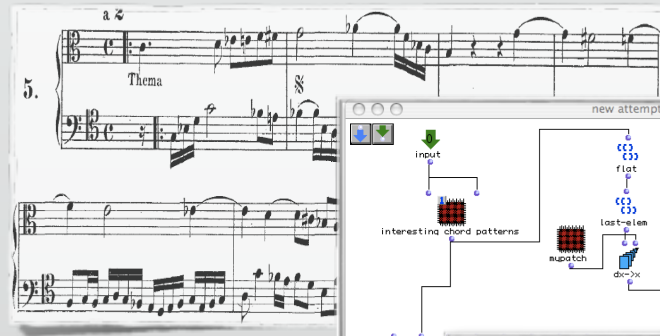


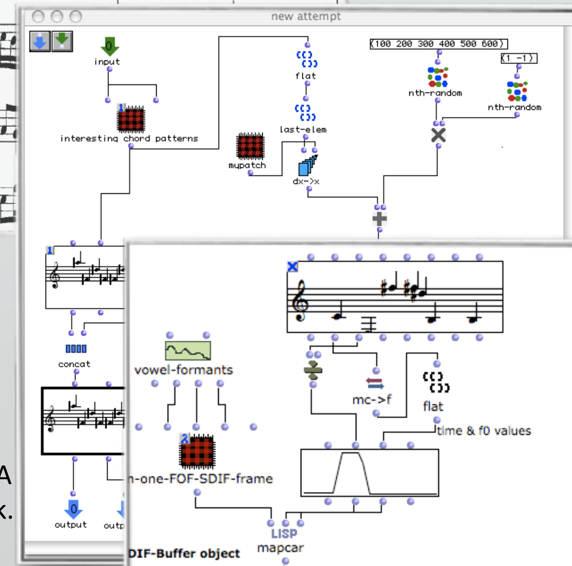




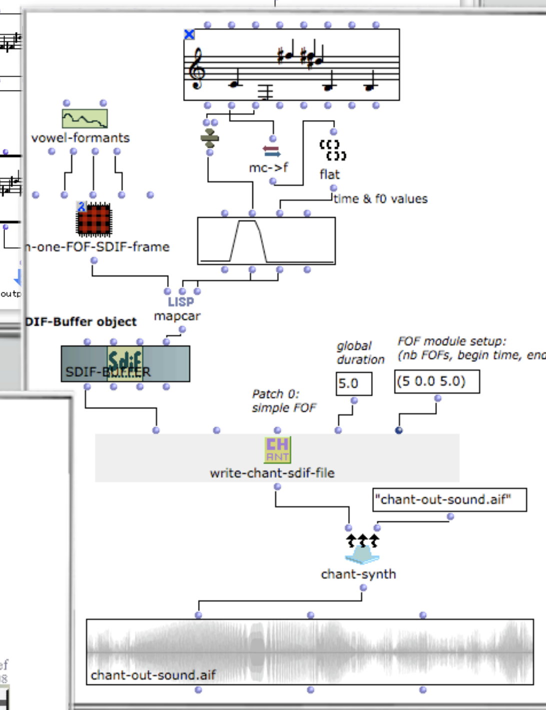
A. Agostini, D. Ghisi, "bach: an environment for computer-aided composition in Max", ICMC 2012.

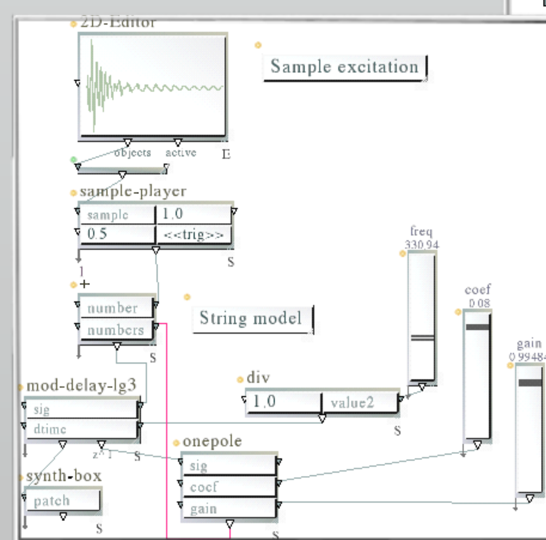
N. Schnell et al. "MuBu & Friends - Assembling Tools for Content Based Real-Time Interactive Audio Processing in Max/MSP." ICMC 2009.





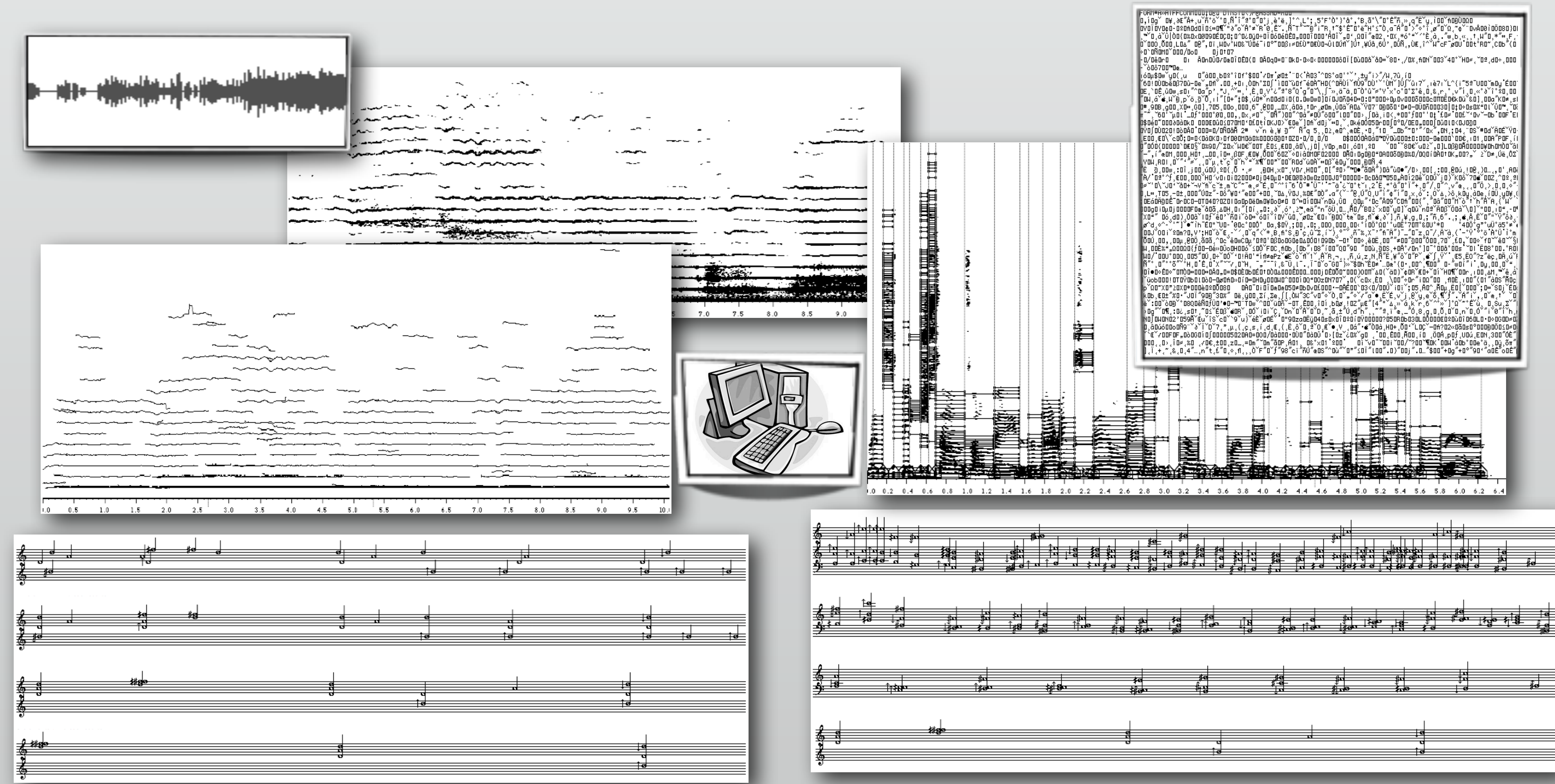
J. Bresson, C. Agon: Musical Representation of Sound in Computer-Aided Composition: A Visual Programming Framework. *Journal of New Music Research*, 36(4), 2007.





M. Laurson, V. Norilo, and M. Kuuskankare, PWGLSynth: A Visual Synthesis Language for Virtual Instrument Design and Control, Computer Music Journal, vol. 29, 2011.

Computer-aided composition at the origins



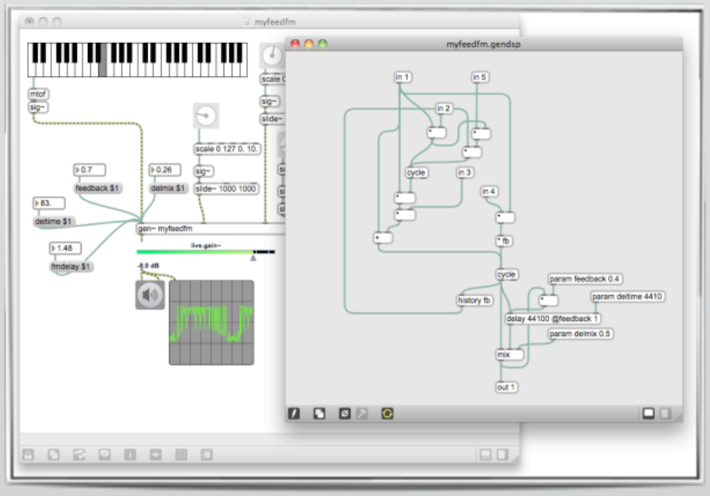
Computer assistance in the exploration, processing and rendering of musical material

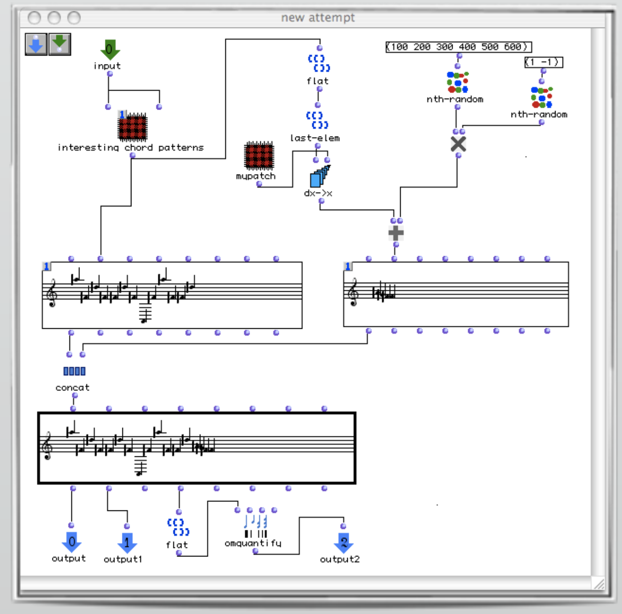
Digital signal processing

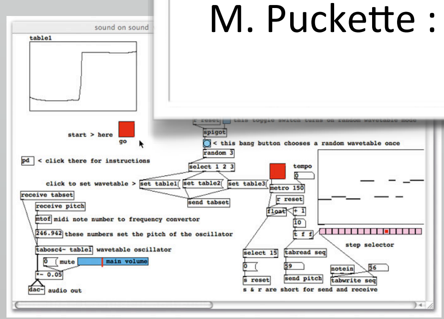
Symbolic music processing

performance

composition





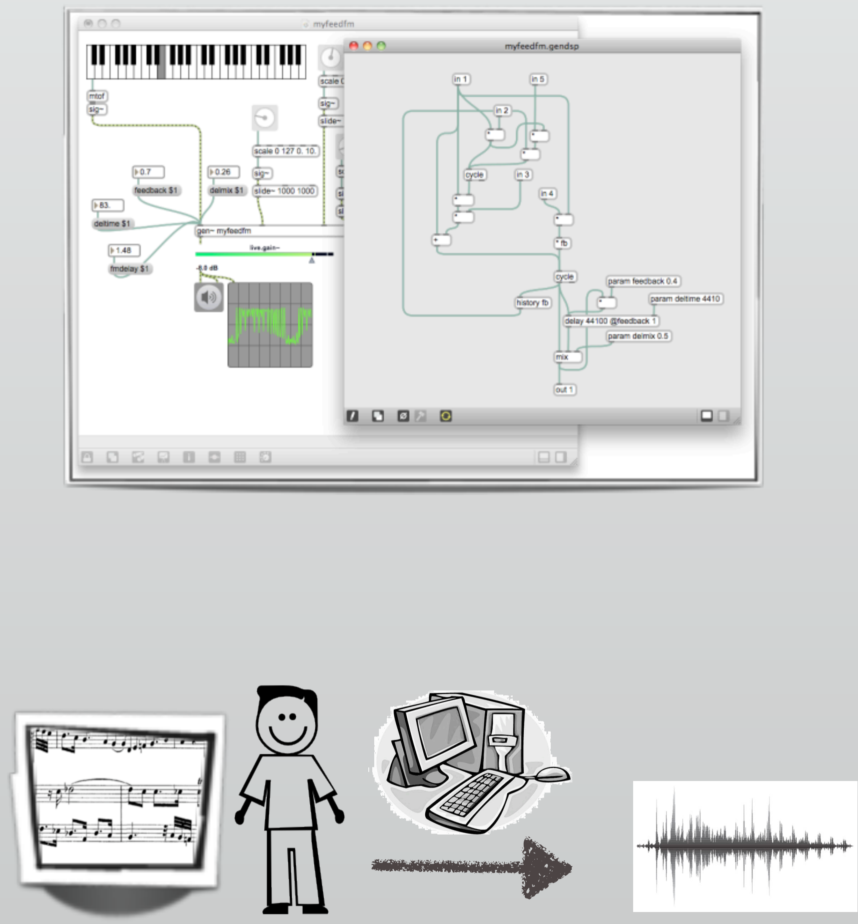


M. Puckette : *A divide between `compositional' and `performative' aspects of Pd*, 1st Pd Convention, Graz, 2004.

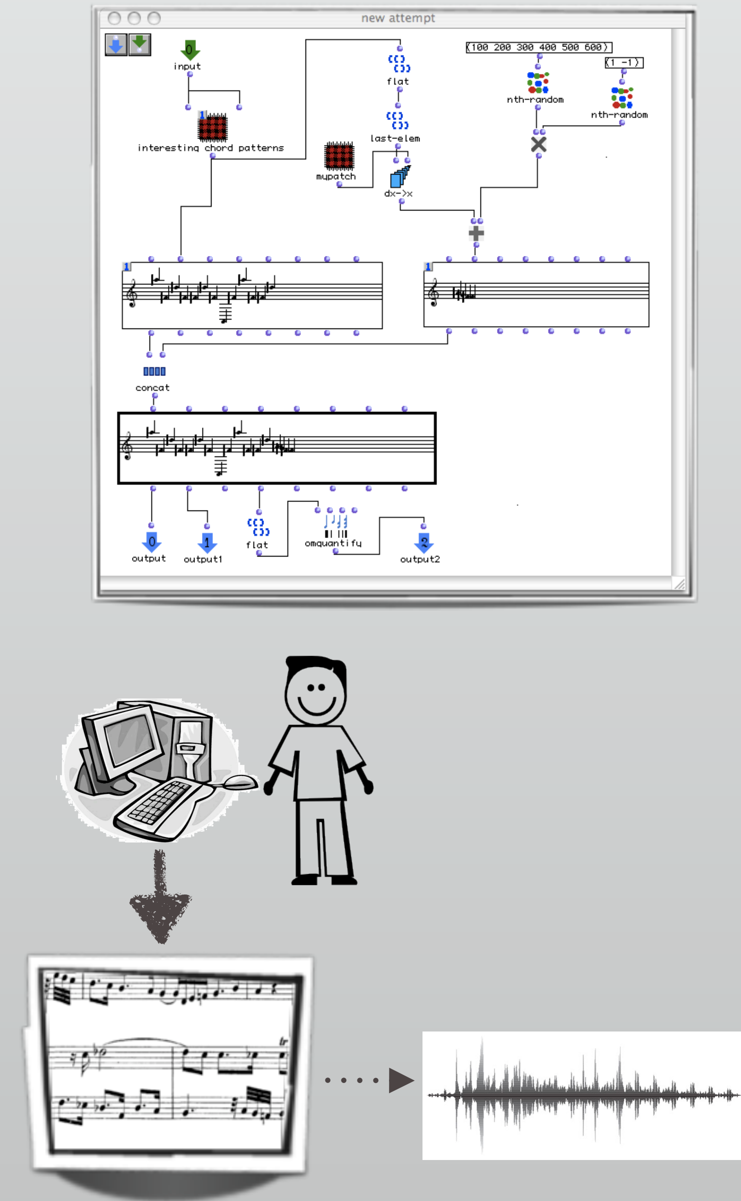
Processes

Data structures

performance

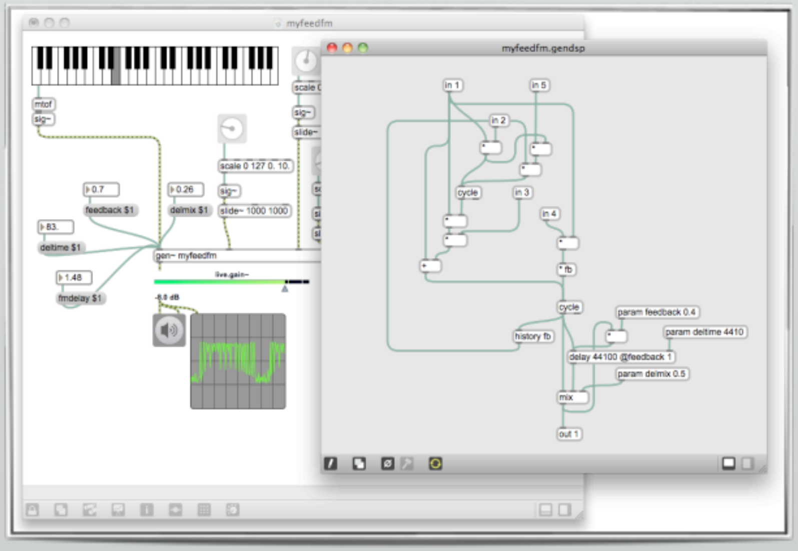


composition

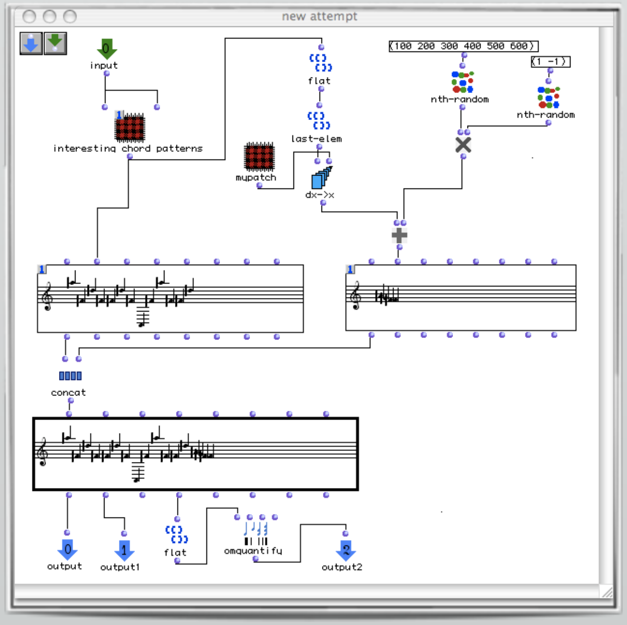


Programming / computation models

Real-time (DSP-oriented) systems:
- imperative dataflow
- continuous input/output (signal, events)



Computer-Aided Composition:
- functional / declarative style
- “out-of-time” calculus - static inputs/outputs



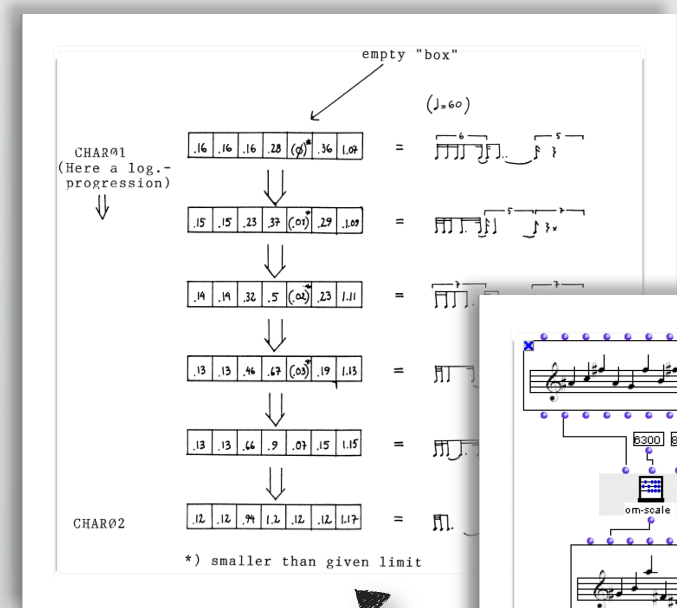
D. Harel, A. Pnueli, “On the Development of Reactive Systems”, *Logics and Models of Concurrent Systems*, 1985.

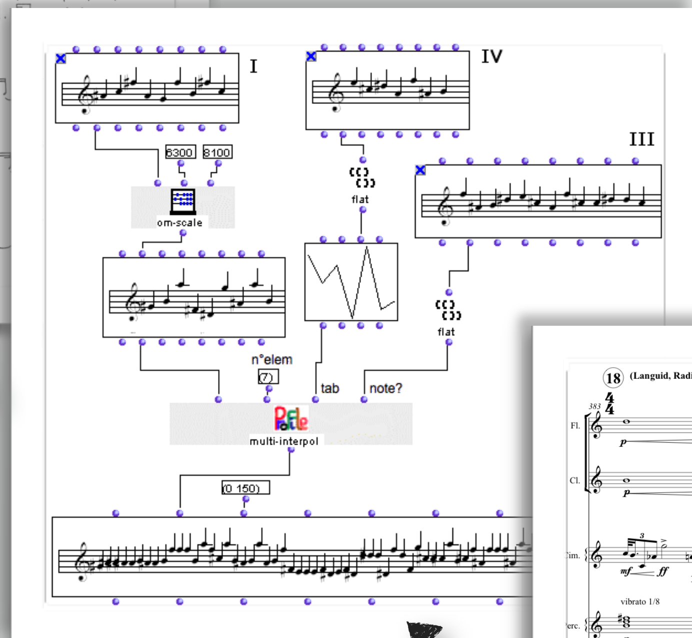
REACTIVE

TRANSFORMATIONAL

Computer-Aided Composition:

FORMALIZATION ⇆ IMPLEMENTATION ⇆ SCORE

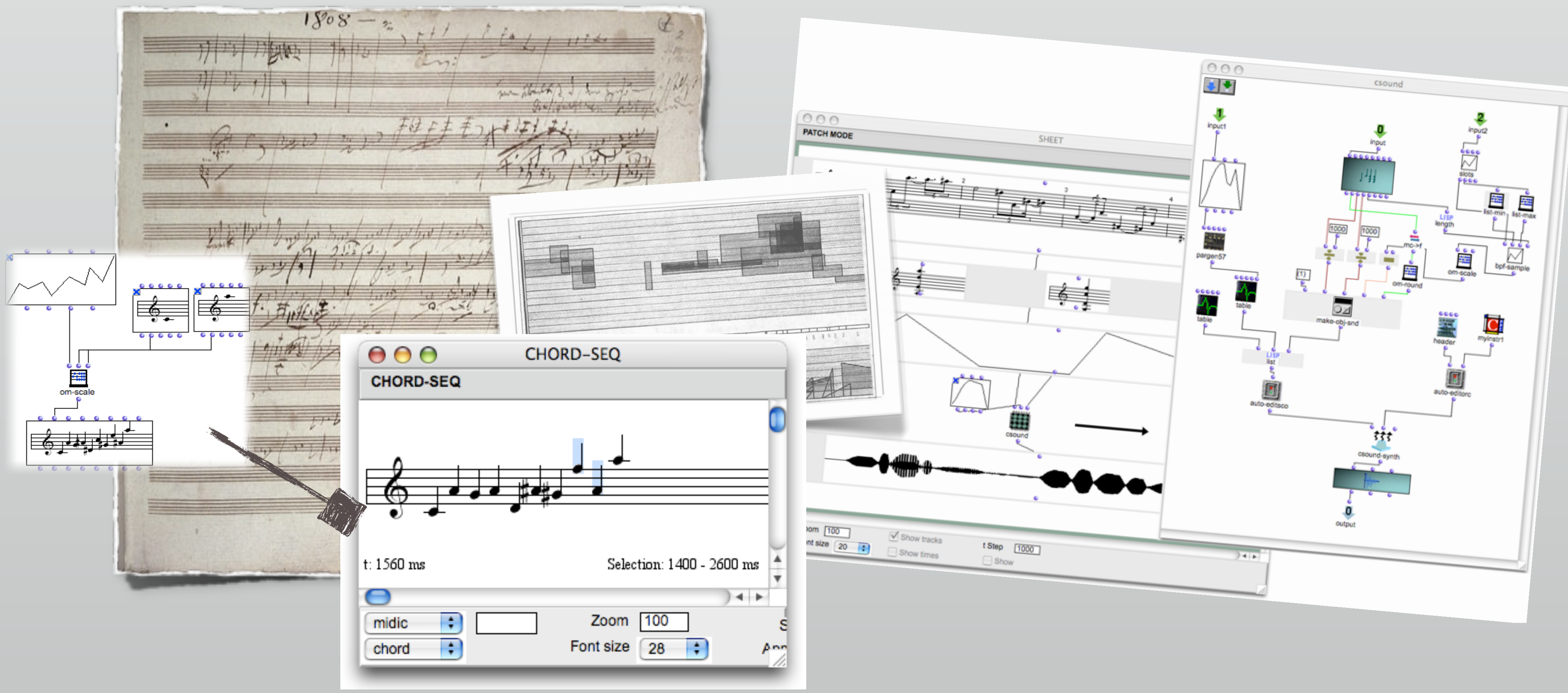




OM visual program = symbolic representation...

- of a musical object/process
- of a compositional model

Describe intentions through a (computer) language



Time of computation vs. Time of music

[...] the major characteristic of Formes constitutes its weakness from our point of view; we think indeed that continuous and irreversible time, necessary for sound synthesis, is not the better paradigm for music composition in general.
G. Assayag, Computer assisted composition today, 1998.

In-time / out-of-time

I. Xenakis. *Formalized music: thought and mathematics in composition* (1971)

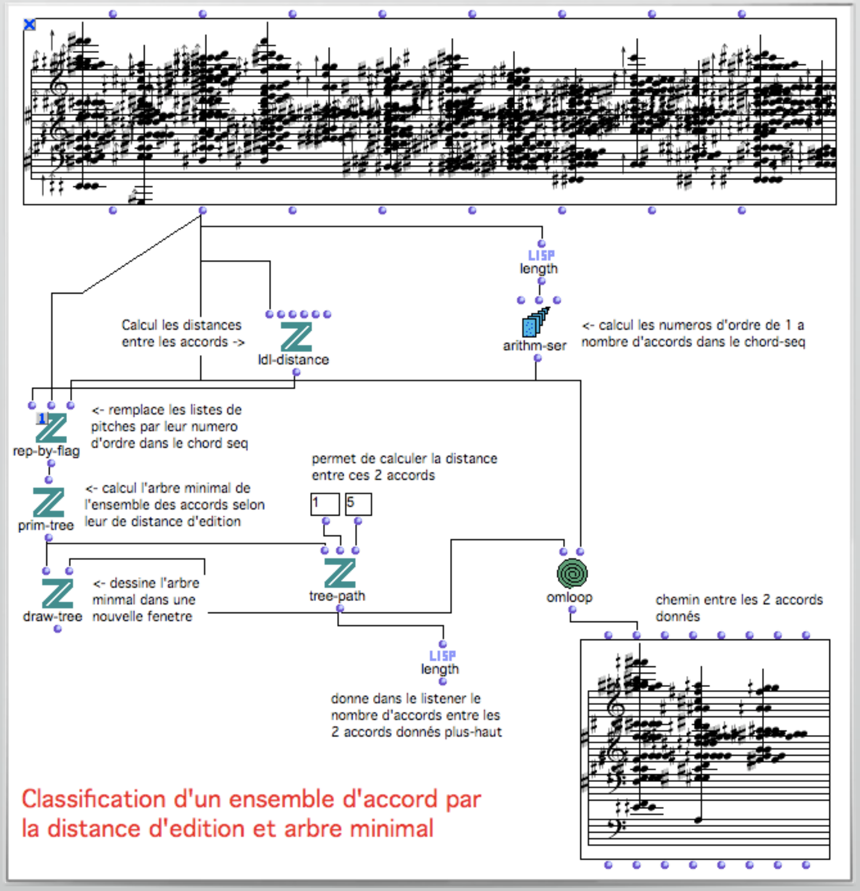
A-series vs B-series

J. McTaggart. *The Unreality of Time* (1908)

J.-L. Giavitto. "Du temps écrit au temps produit en informatique musicale" (to appear)

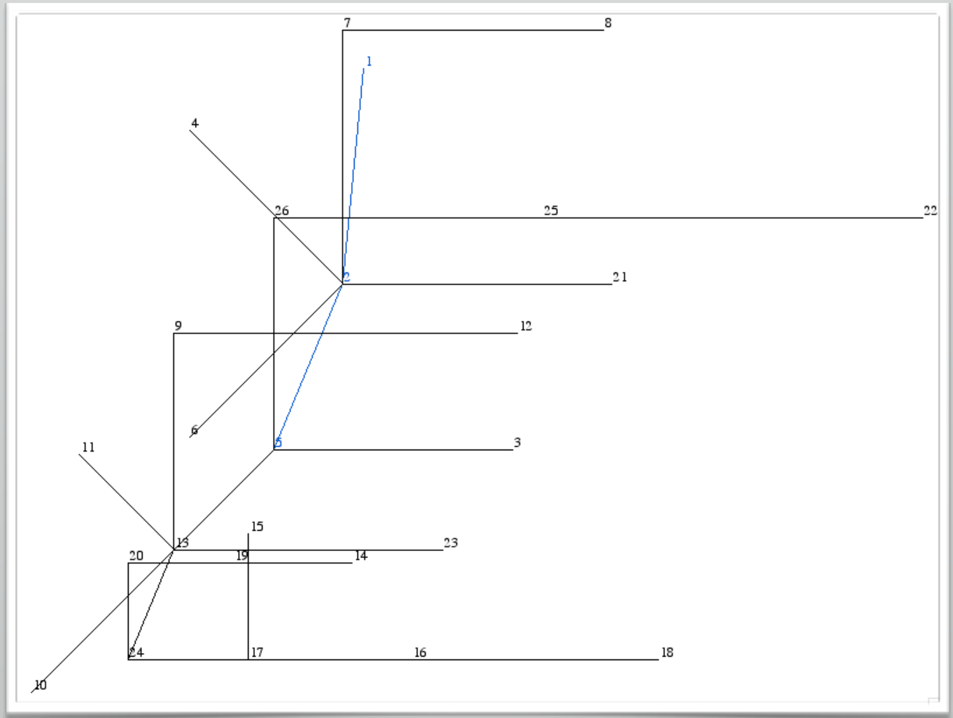
Contruction of temporal forms :
A few examples of CAC (from *The OM Composer's Book*)

Ph. Leroux
VOI(REX) (2002)

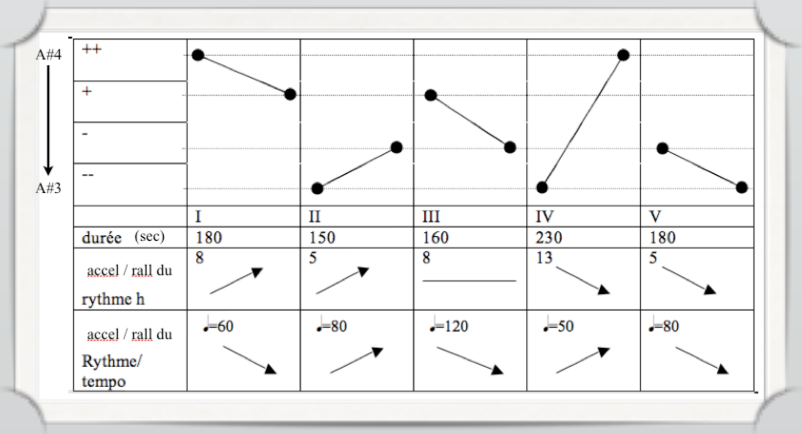


combinatorial optimization problems

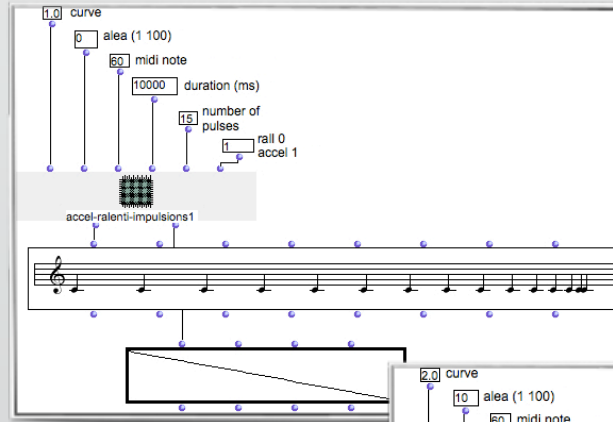
Minimum Weight Spanning Tree
= optimal arrangement of the chords
following a given classification criteria

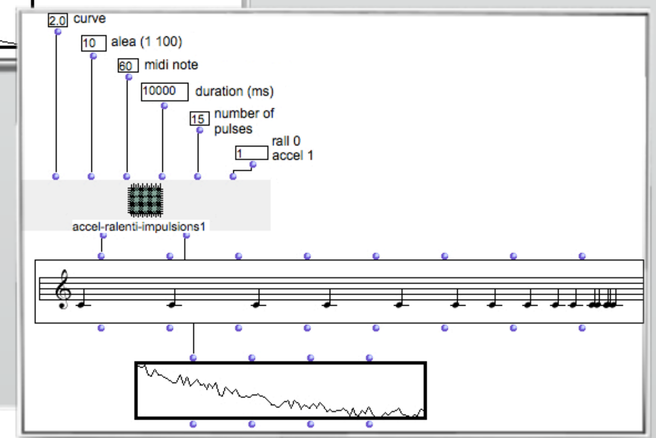


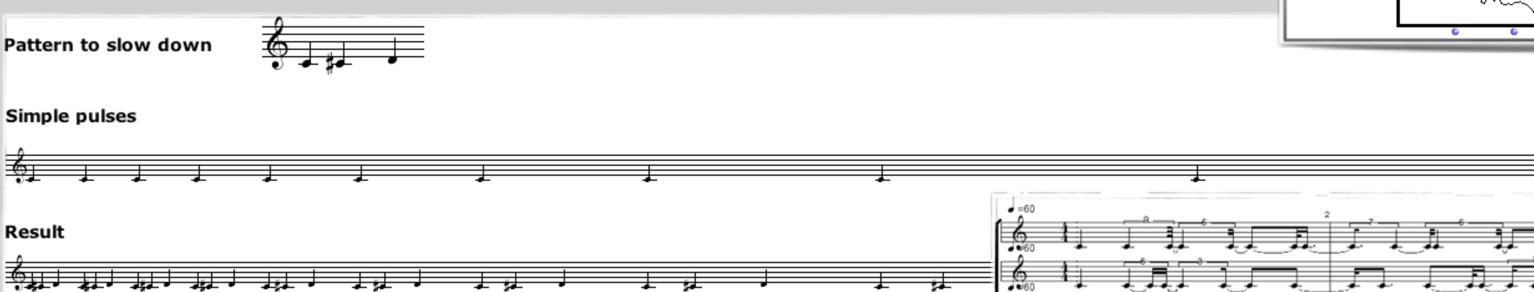
G. Lorieux
Langage de l'ombre
(2006)

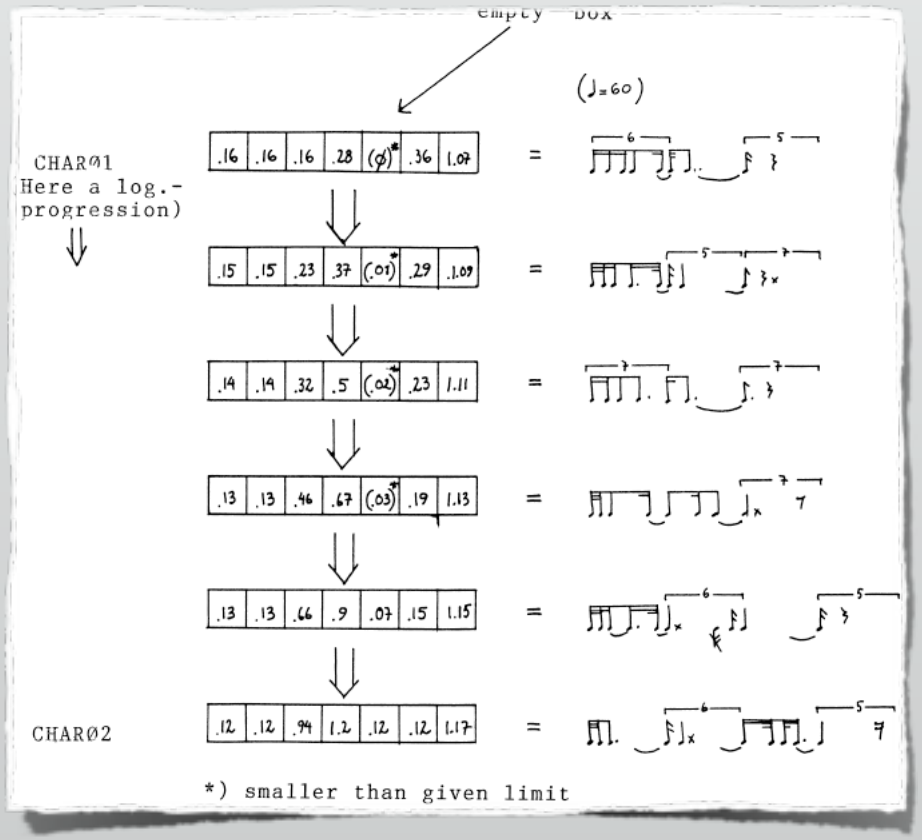


	I	II	III	IV	V
durée (sec)	180	150	160	230	180
accel / rall du rythme h	8 ↗	5 ↗	8 —	13 ↘	5 ↘
accel / rall du Rythme/ tempo	♩=60 ↘	♩=80 ↗	♩=120 ↘	♩=50 ↗	♩=80 ↘

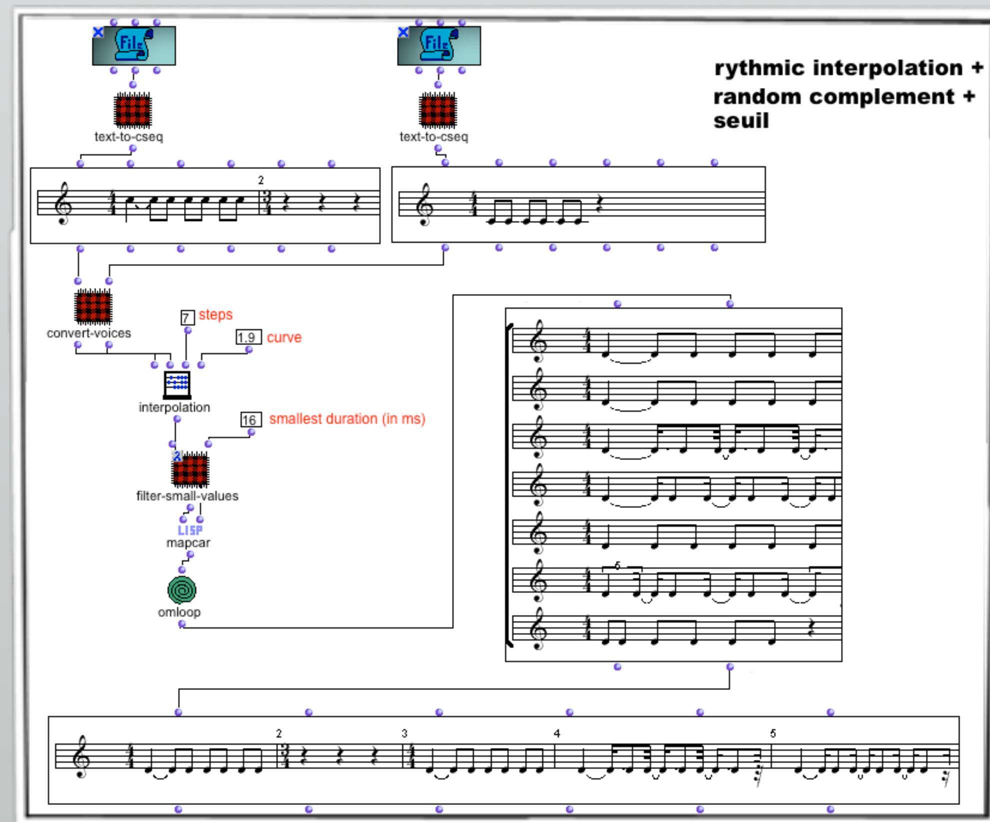






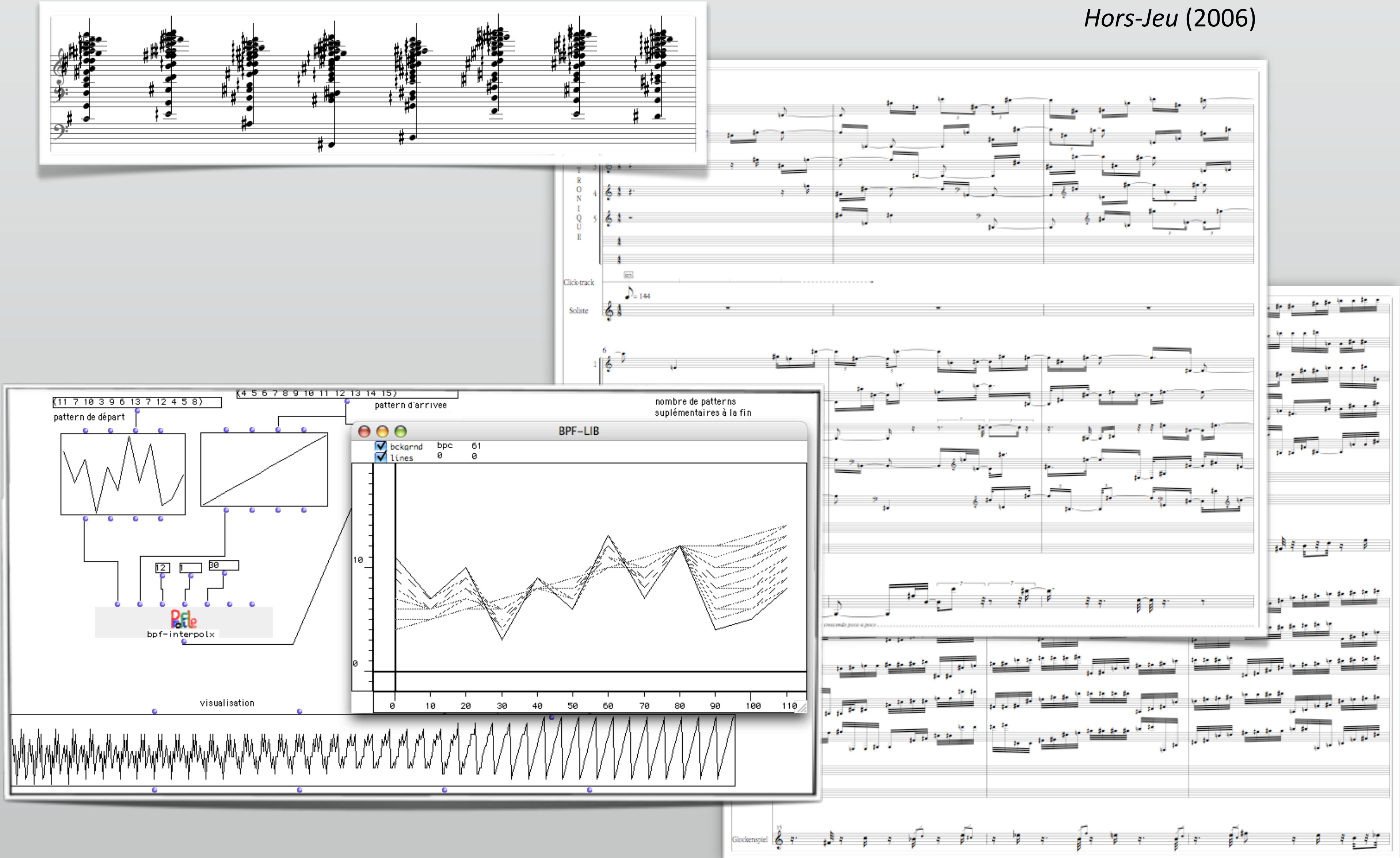


A. Schaathun
Double Portrait (2006)

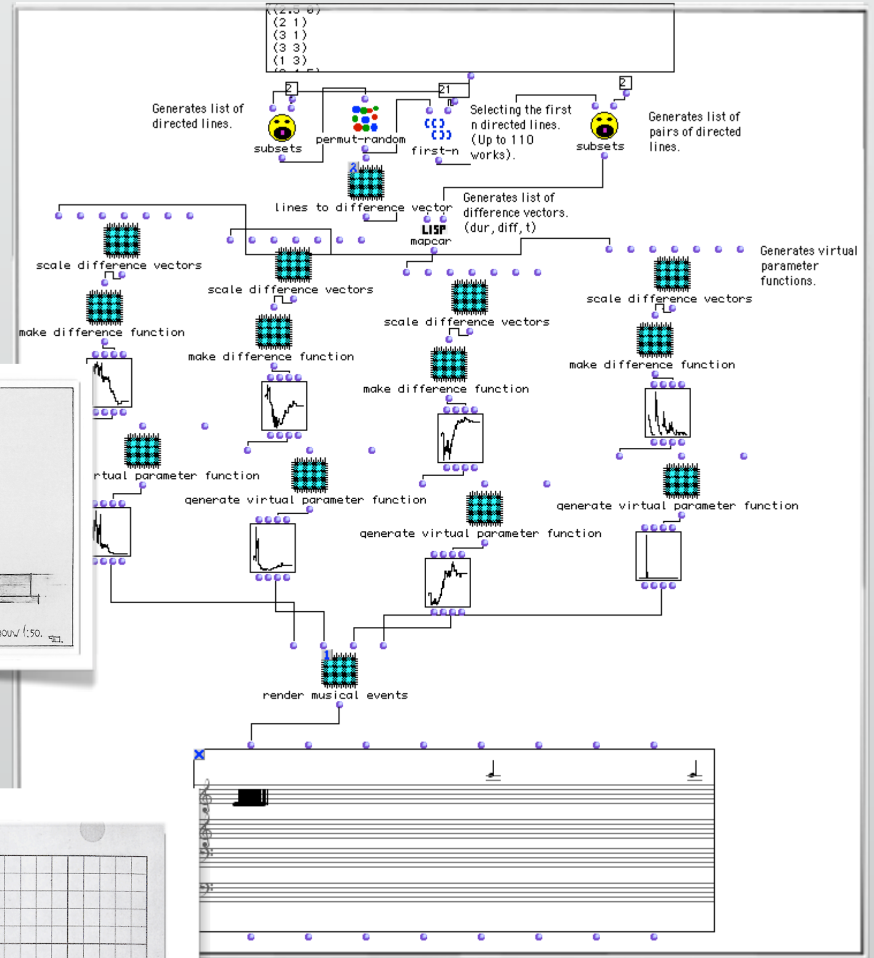


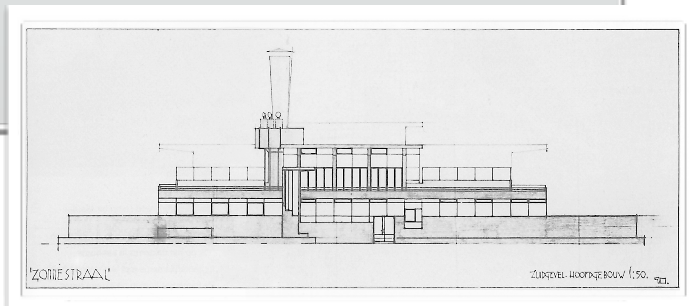
Ph. Hurel / E. Daubresse

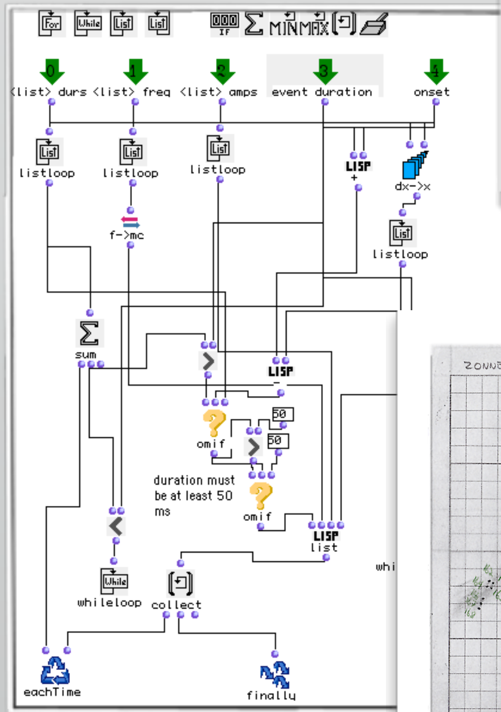
Hors-Jeu (2006)

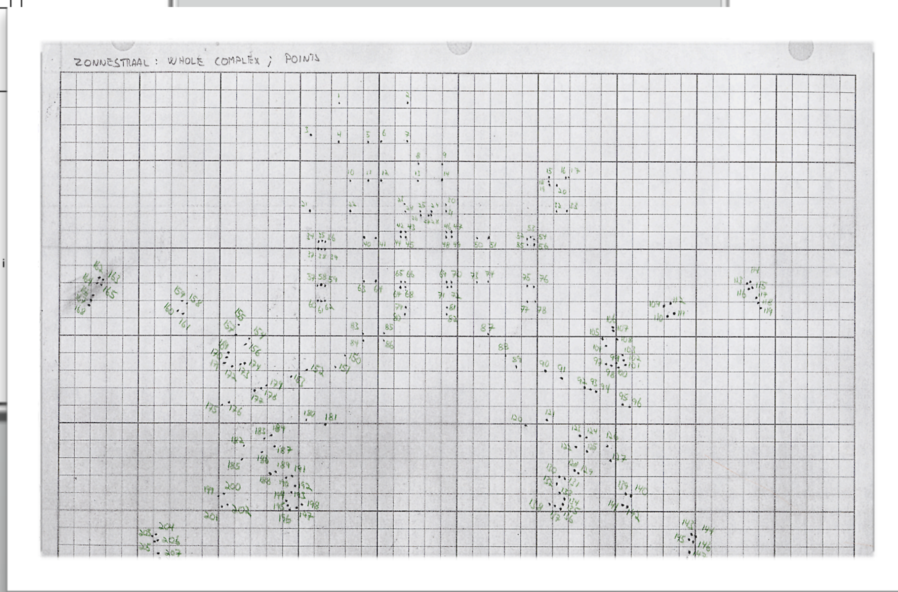


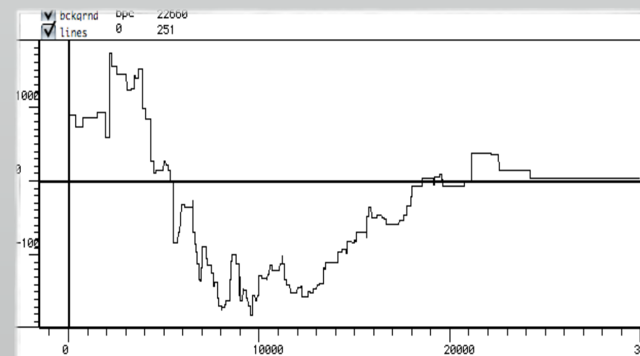
C. Jaksjo
Undergrounded [Zoonestraal] I (2002)
Zoonestraal (2008)



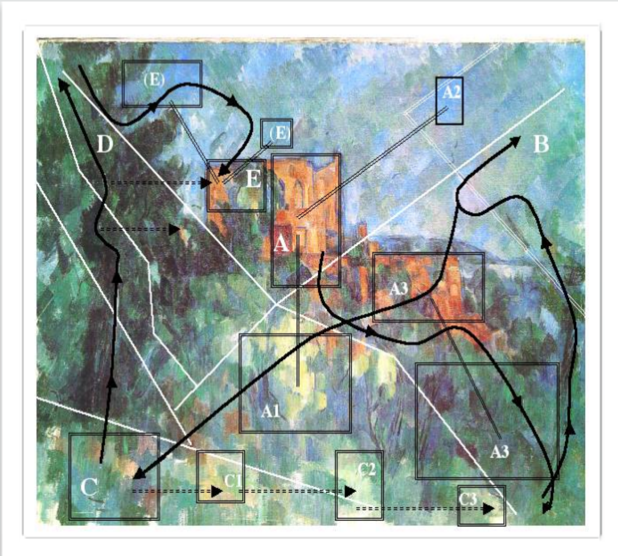


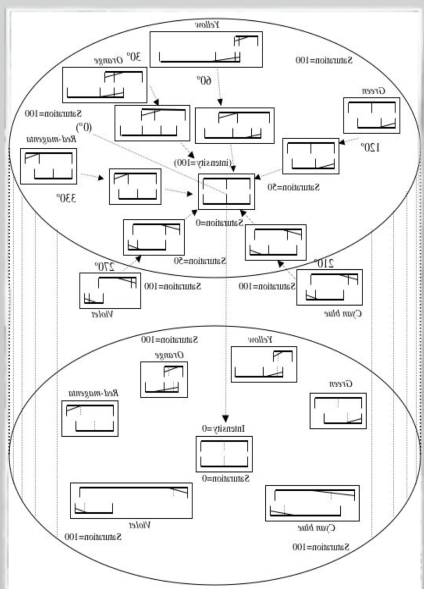


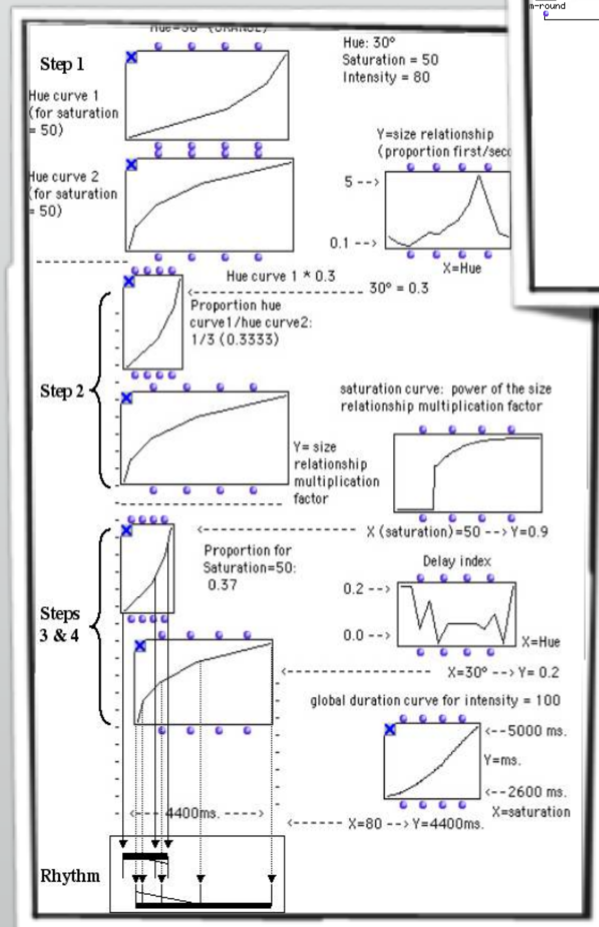


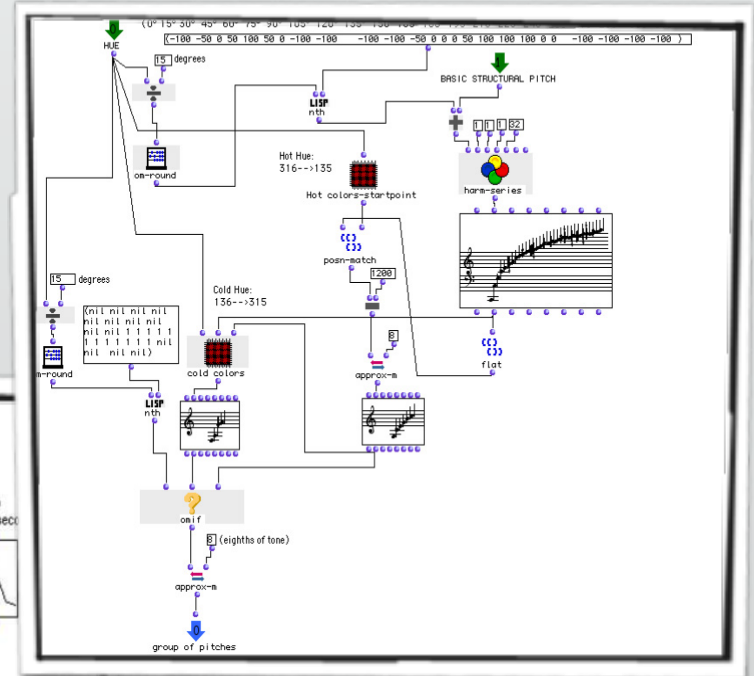


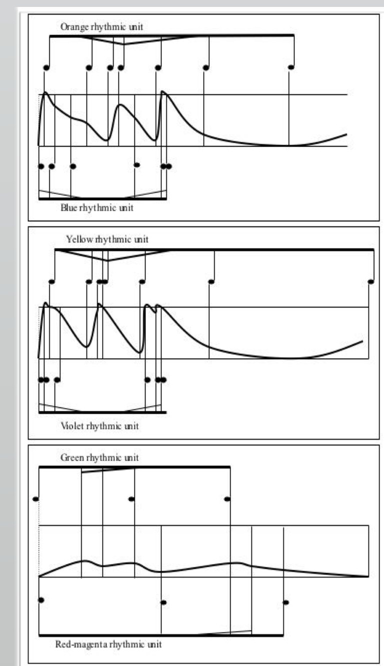
H. Parra
Strette (2006)



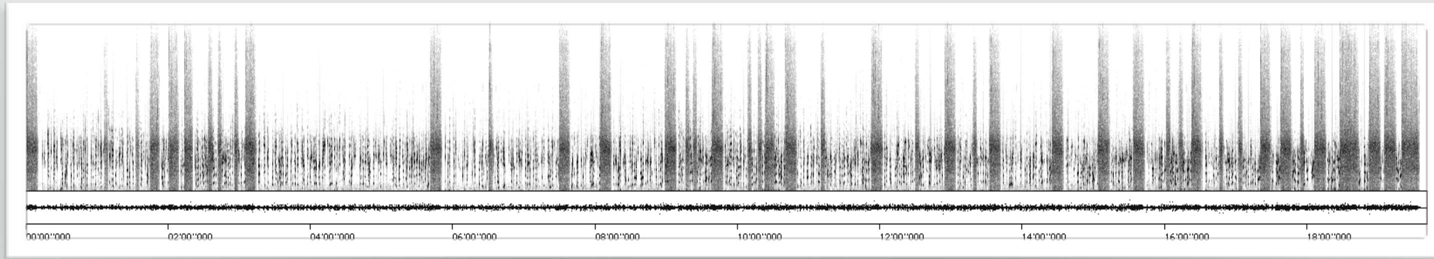


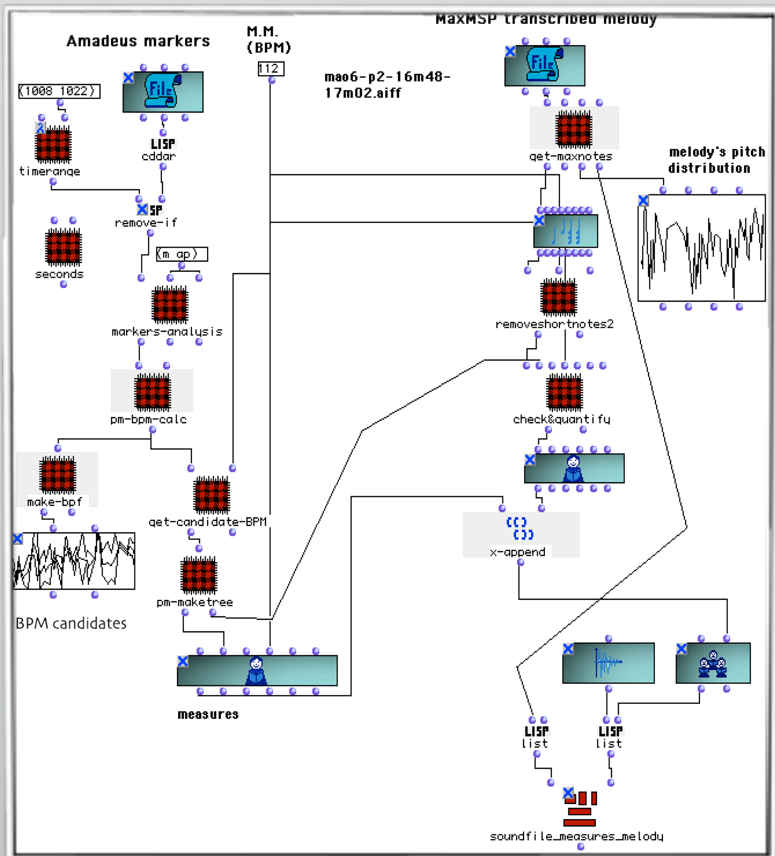


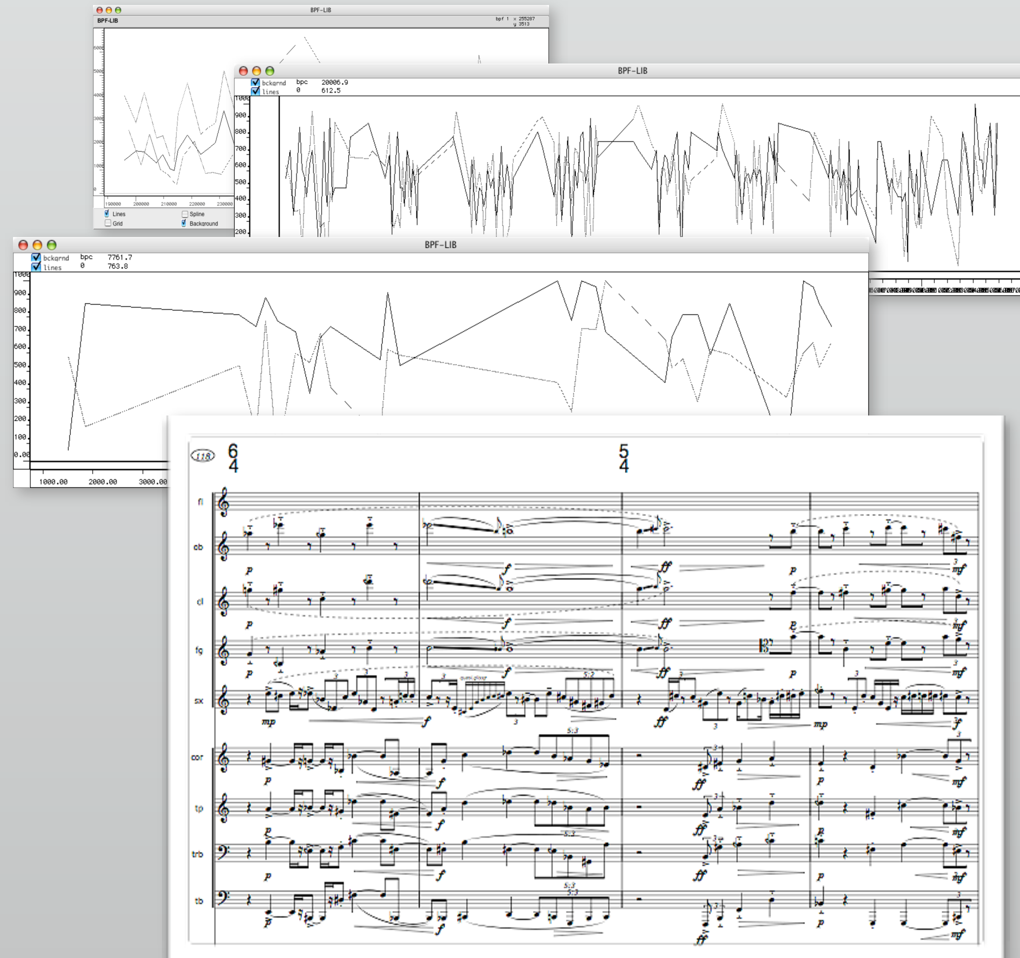




P. Linborg
TreeTorika
(2006)

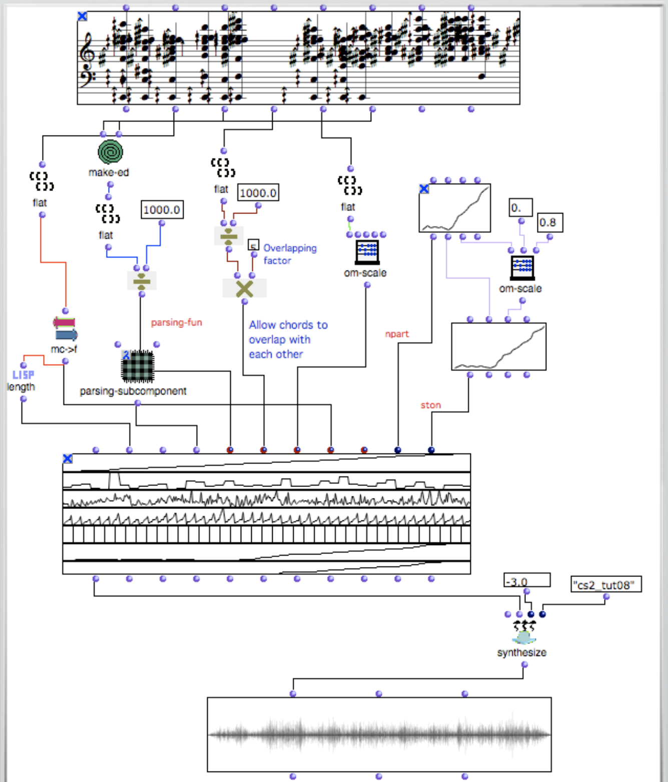




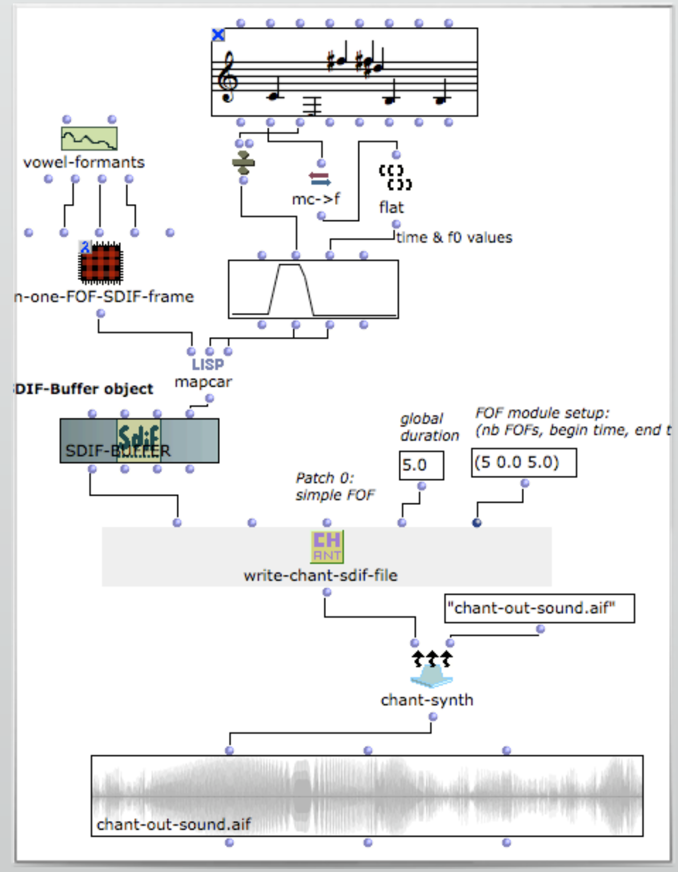


... contruction of large-scale temporal forms

Applies in the sound processing domain too:



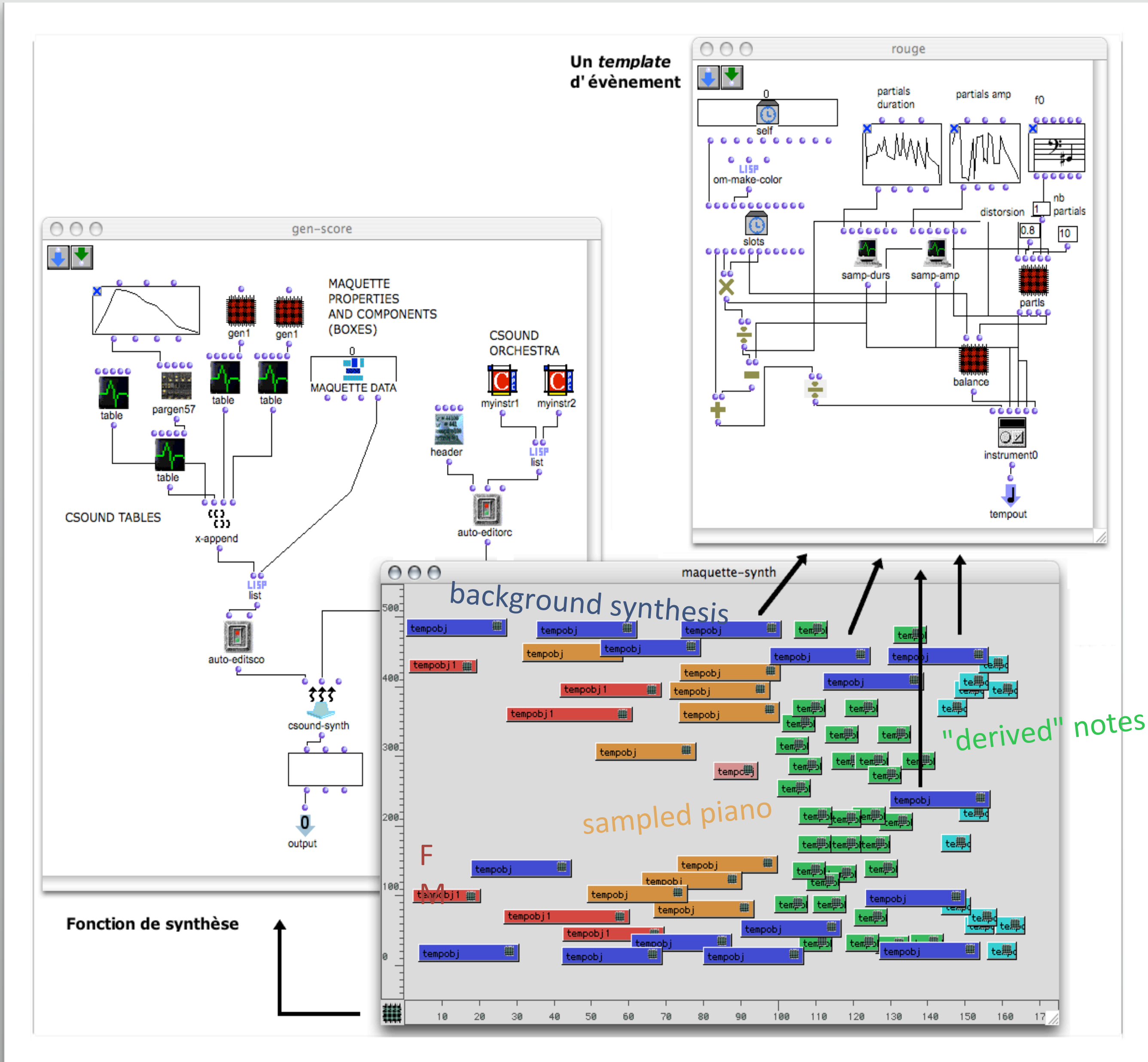
J. Bresson, M. Stroppa, C. Agon : *Generation and Representation of Data and Events for the Control of Sound Synthesis*, Proc. Sound and Music Computing Conference, Lefkada, Greece, 2007.



J. Bresson, R. Foulon, M. Stroppa, *Reduction as a Transition Controller for Sound Synthesis Events*. Workshop on Functional Art, Music, Modeling and Design, Boston, MA, USA, 2013.

=> Implementation of the compositional electroacoustic models and processes
- Symbolic approach/representation of sounds
- Musical sound formalisation

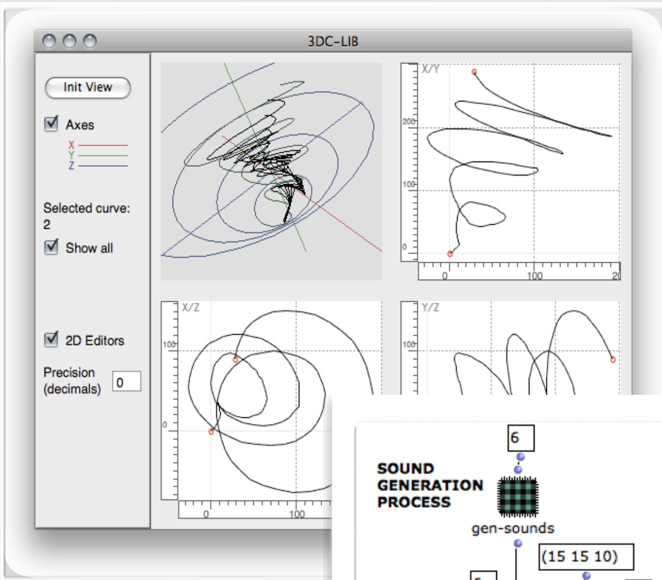
... contruction of large-scale temporal forms (+ sound synthesis)



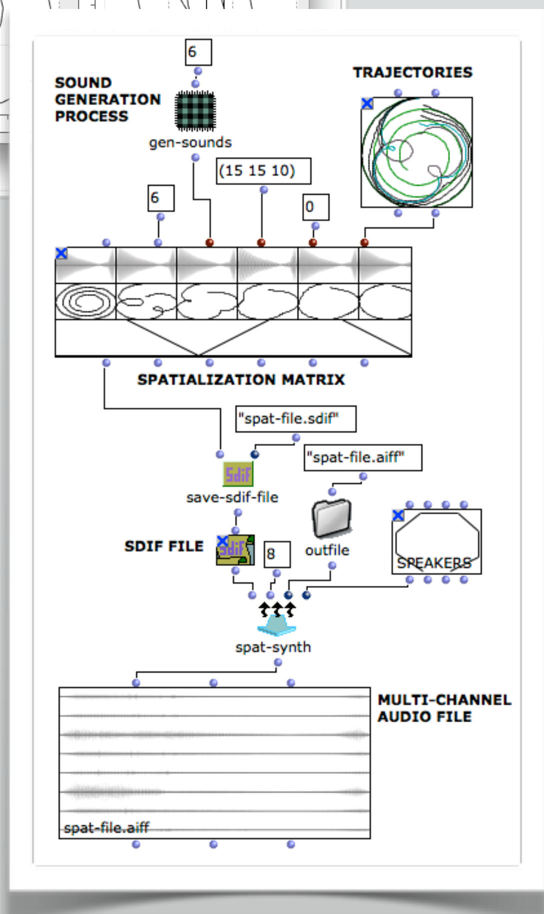
[0'35'']

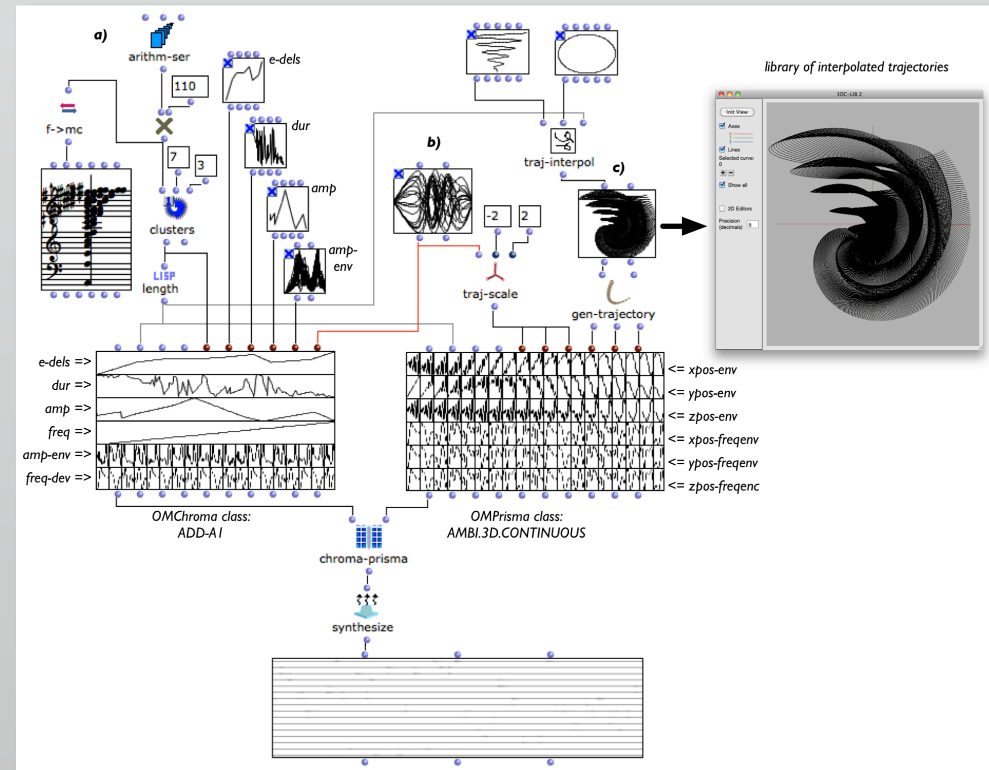
by Karim Haddad

[... and sound spatialization]



J. Bresson, “Spatial Structures Programming for Music”. AAMAS’12
Spatial Computing Workshop, Valencia, 2012.



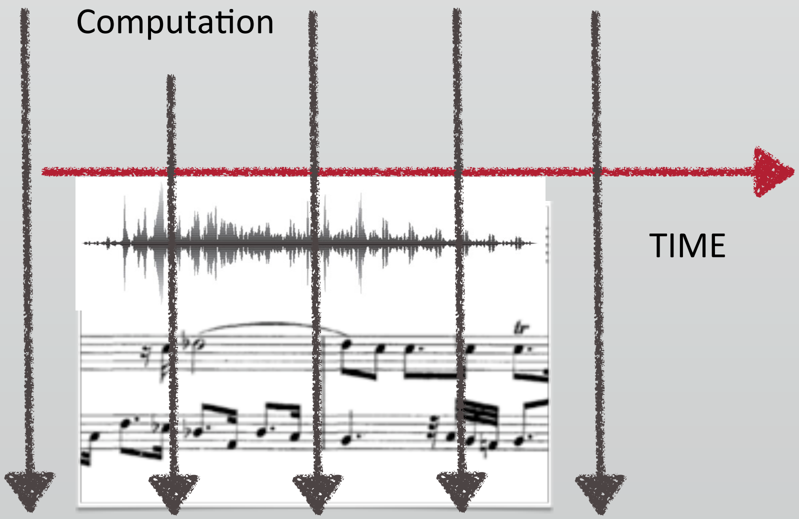


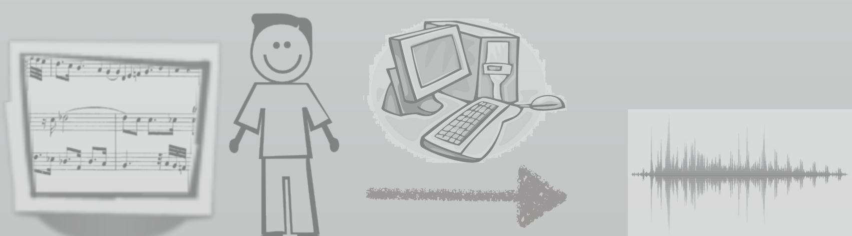
M. Schumacher, J. Bresson (2010) Spatial Sound Synthesis in Computer-Aided Composition. Organised Sound, 15(3).

Time of computation vs. Time of music

(reactive) real-time systems

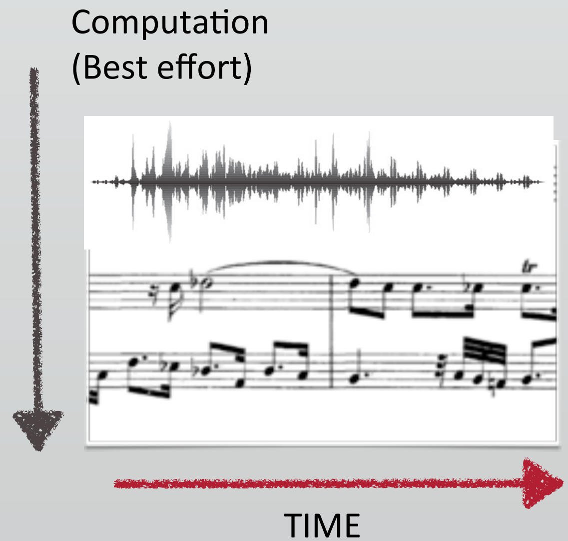
[Max]

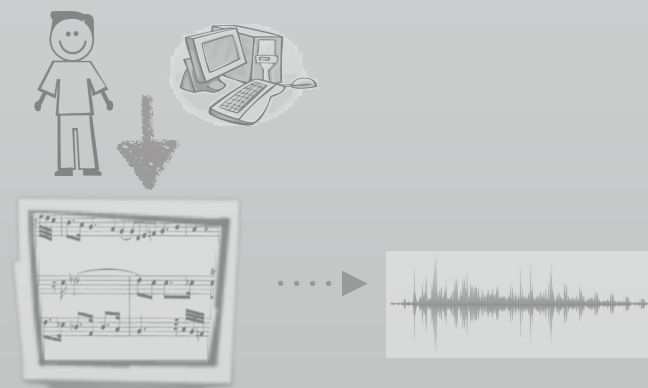




(transformational) computer-aided composition

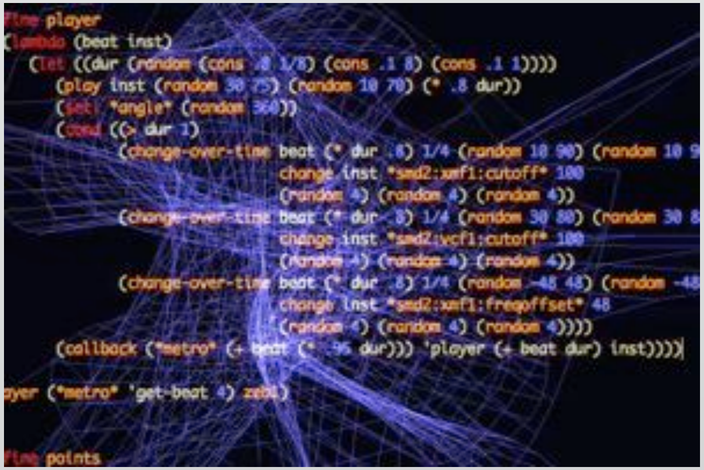
[OM]





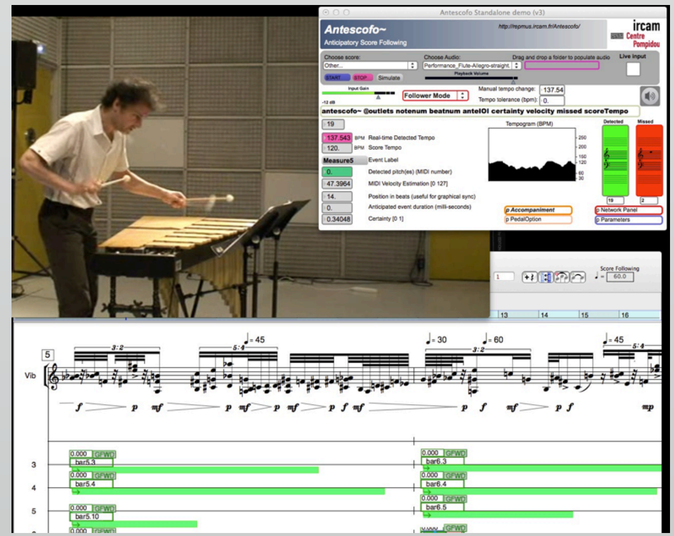
where the distinction gets blurred...

Live coding



Impromptu

Score following



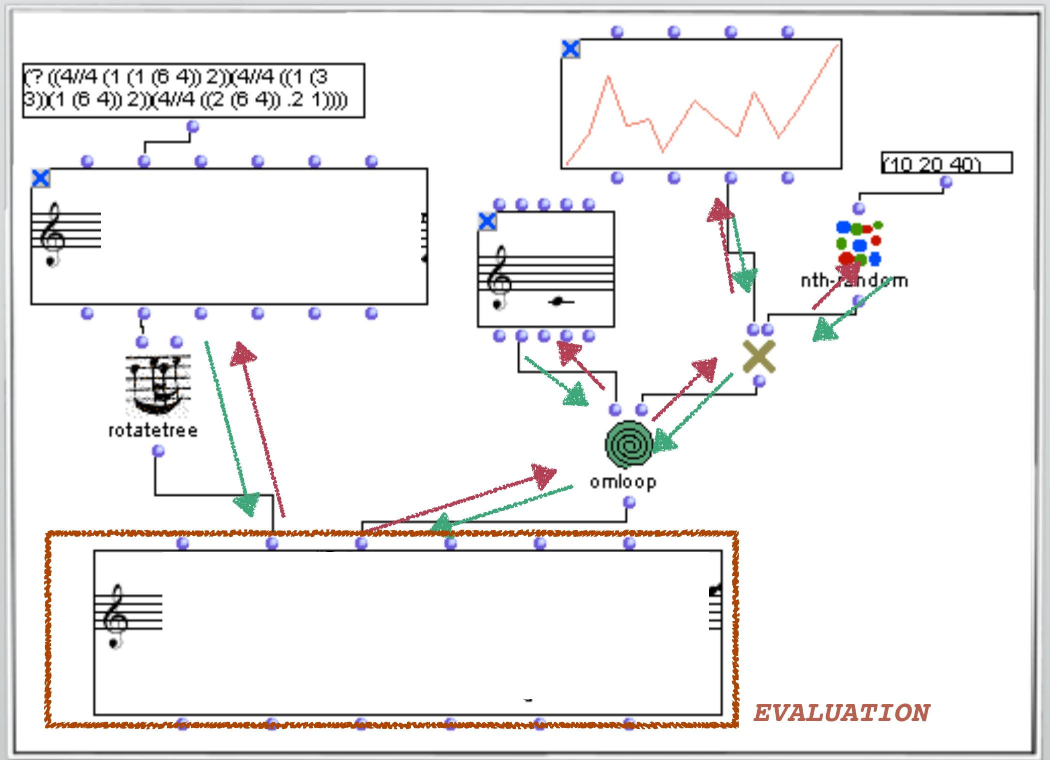
Antescofo

Computer improvisation systems

OMax

Toward a reactive computation model in OM

"demand-driven"



reactive

=> DEMO OM REACTIF

J. Bresson, C. Agon, G. Assayag. "Visual Lisp/CLOS Programming in OpenMusic"
Higher-Order and Symbolic Computation, 22(1), 2009.

Toward a reactive computation model in OM

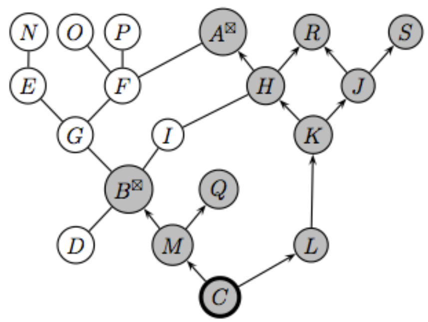


Figure 3: Call graph of the evaluation of **C** in Fig. 1.

Staggered Evaluation. The previous framework leads to a *staggered evaluation*

$$[\![\cdot]\!]^t(\cdot) : \mathcal{B} \times \mathbb{N} \to \mathcal{V},$$

where only the values of the boxes required to compute the outputs of r^t are updated:

$$[\![b]\!]^t(k) = \begin{cases} \star & \text{if } b \notin \mathsf{B}^t \\ e^t(b,k) & \text{if } \mathit{flag}^t(b) = \boxed{e} \\ [\![b]\!]^{t-1}(k) & \text{if } \mathit{flag}^t(b) = \boxtimes \\ u & \text{if } \mathit{flag}^t(b) = \boxed{\lambda} \\ [\![b]\!]_k(v_1,\ldots,v_{in(b)}) & \text{if } b \in \uparrow\{r^t\} \\ [\![b]\!]^{t-1}(k) & \text{otherwise} \end{cases}$$

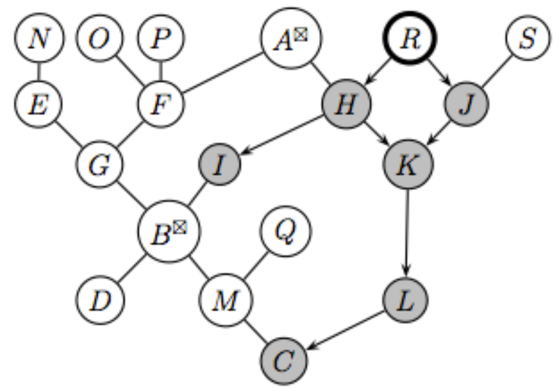
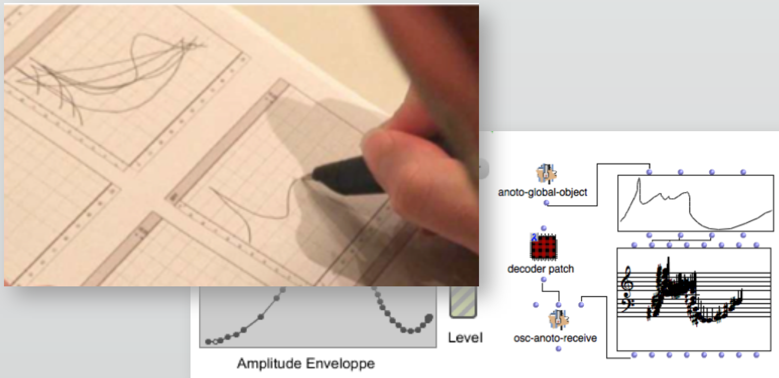


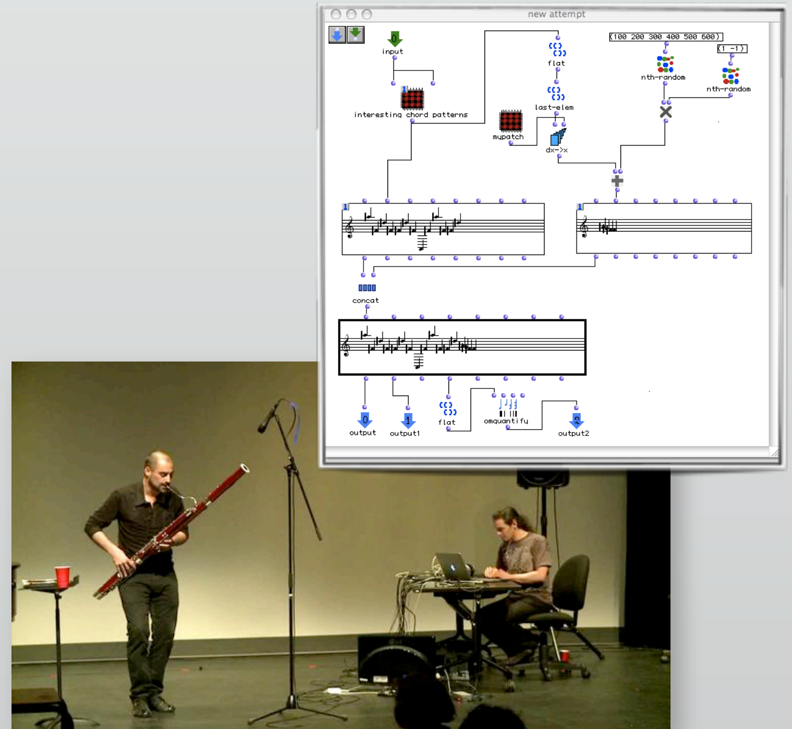
Figure 4: Propagation of event $\{\mathbf{R}\}$ in the *reactive* patch from Fig. 1. We suppose that all boxes are active. Notice that $\mathbf{R} \notin \downarrow\{\mathbf{R}\}$: the values associated to **R** are obtained by edition, not by evaluation.

J. Bresson, J.-L. Giavitto, “A Reactive Extension of the OM Visual Programming Language”, 2013.

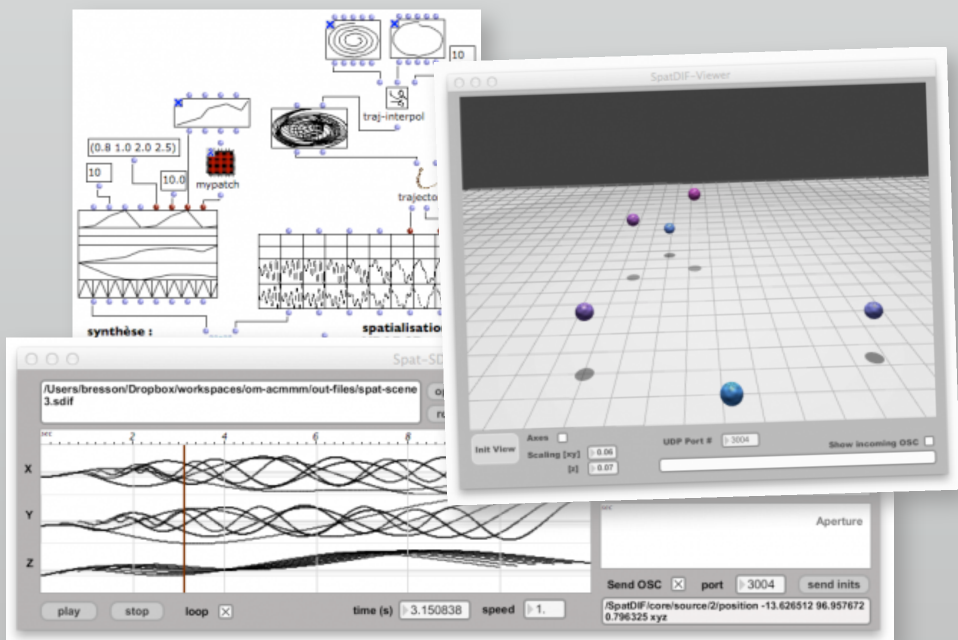
applications / perpsectives



Gesture devices and integration
(J. Garcia, D. Scwartz)



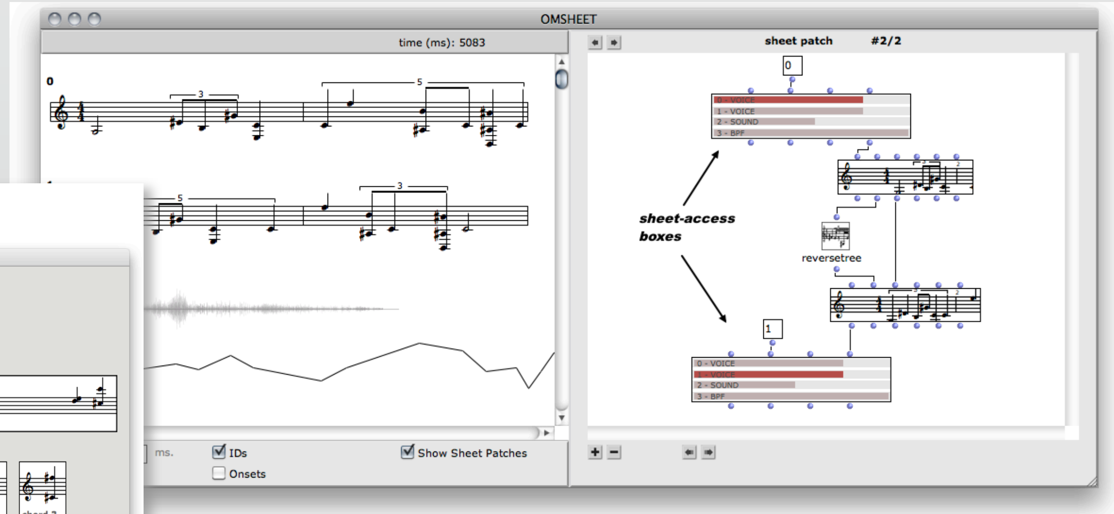
Controlled improvisation systems
(J. Nika / Improtek)

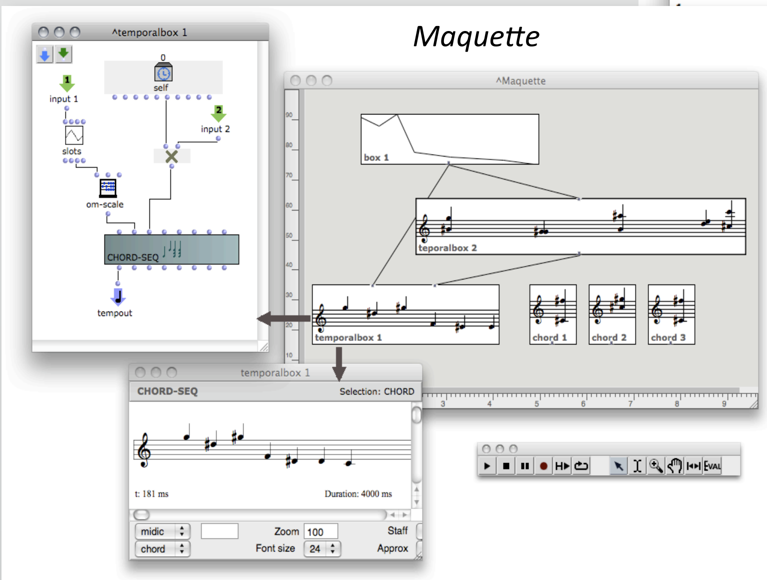


Control prpcesses for granular sounds and spatialization (T. Carpentier, R. Gottfrield, D. Scwartz)

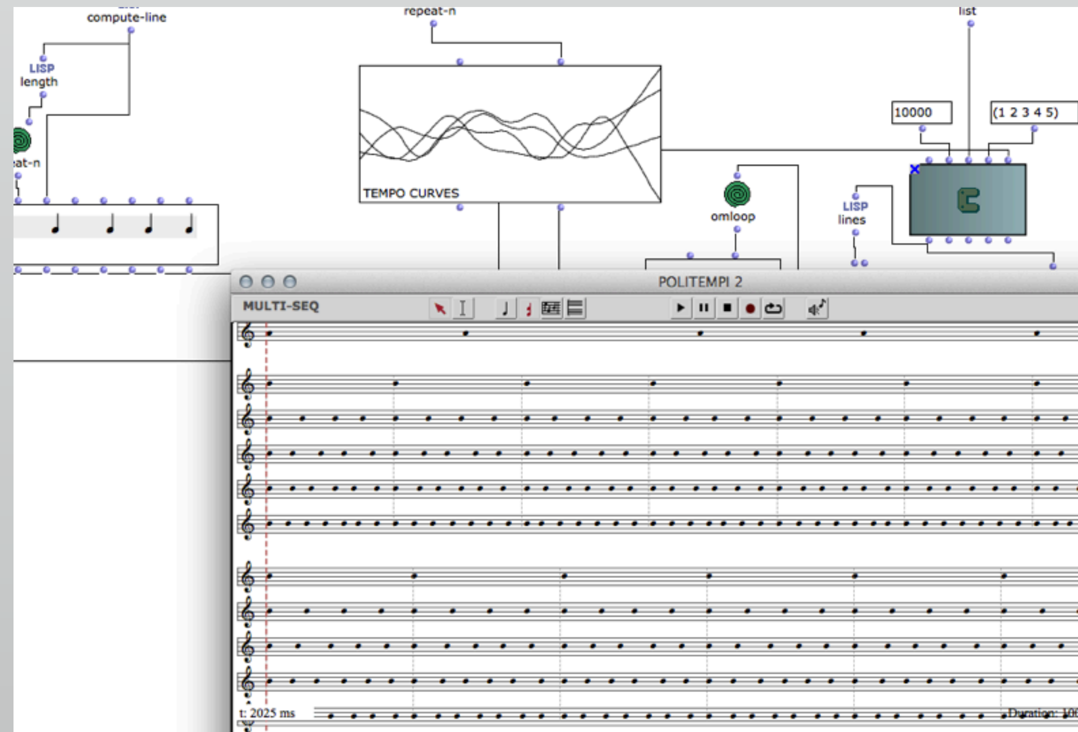
applications / perpsectives

OMSheet





Interaction in larger-scale time structures / dynamic scheduling
(D. Bouche)



Dynamic/interactive control of tempo and rhythmic structures
(J. MacCallum, F. Jacquemard)