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# Real-Time Corpus-based Concatenative Synthesis with CataRT

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<http://imtr.ircam.fr> CataRT releases

<http://ftm.ircam.fr> FTM for Max 5



# Principle of CBCS

- **Corpus-based**

sounds + segmentation + **descriptors**  
(timbre, metadata, classes)

- **concatenative**

grains + overlap + chaining

- **real-time synthesis**

interactive + explorative (navigation)



# Motivation and Approach

- work with all the nuances of *real* sound
- large sound databases exist, ready to use
- new method → new sound creation
- *data-driven* vs. *rule-based* approach
- general superiority of data-driven approaches in many other domains



# Influences and Links

- Inspired by concatenative speech synthesis
- CBCS in real-time (as implemented in CataRT) can be seen as a content-aware extension to granular synthesis:
  - providing direct access to specific sound characteristic
  - not restricted to selection by position in a sound



# Applications of CBCS

- Interactive exploration of sound databases (*browsing*)
- Resynthesis of an audio target (*mosaicing*)
- Texture synthesis (*ambiences, soundtracks*)
- High-level instrument synthesis (example: *Synful*)
- Expressive speech synthesis



# A Short History of Data-Driven Synthesis

## I.Prehistory (1948)

- Concrete and early electronic music

## II.The Classics — revisited (1980, 1990)

- Sampling
- Granular Synthesis
- John Oswald

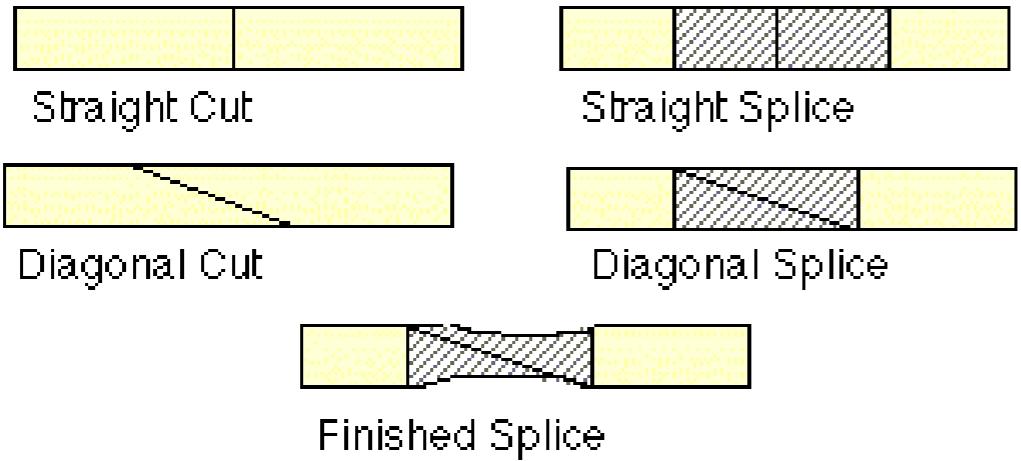
## III.The Modern Times (2000)

- many research projects, often in mutual ignorance



# Tape splicing

Karlheinz Stockhausen:  
Étude des 1000 collants (1952)

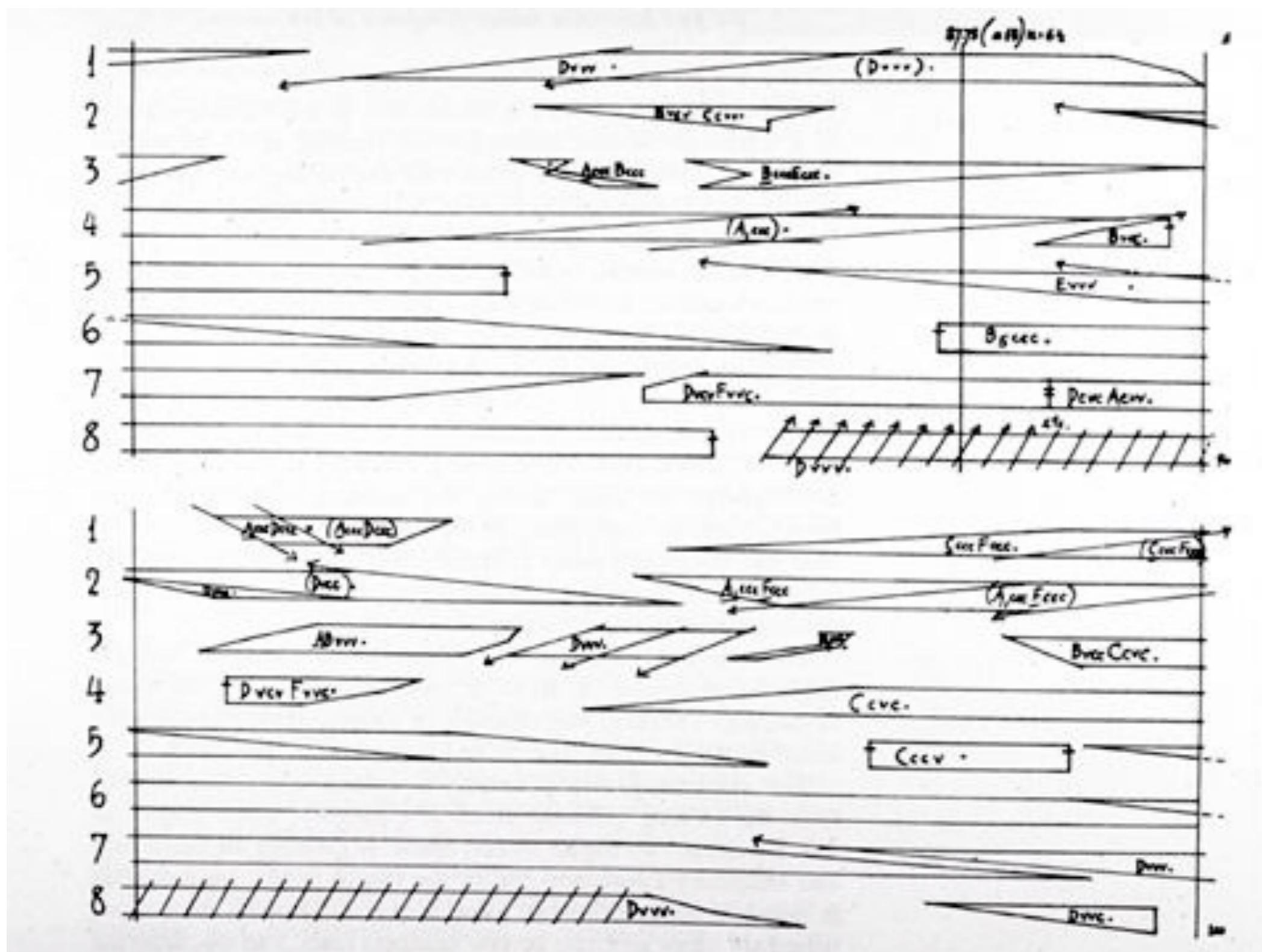


- A soft attack or decay
- B combined attack and decay of two sounds
- C medium attack or decay
- D hard attack or abrupt finish
- E softer and less abrupt than D

[figures: Mikhail Malt]



# John Cage: *Williams Mix* (1953)

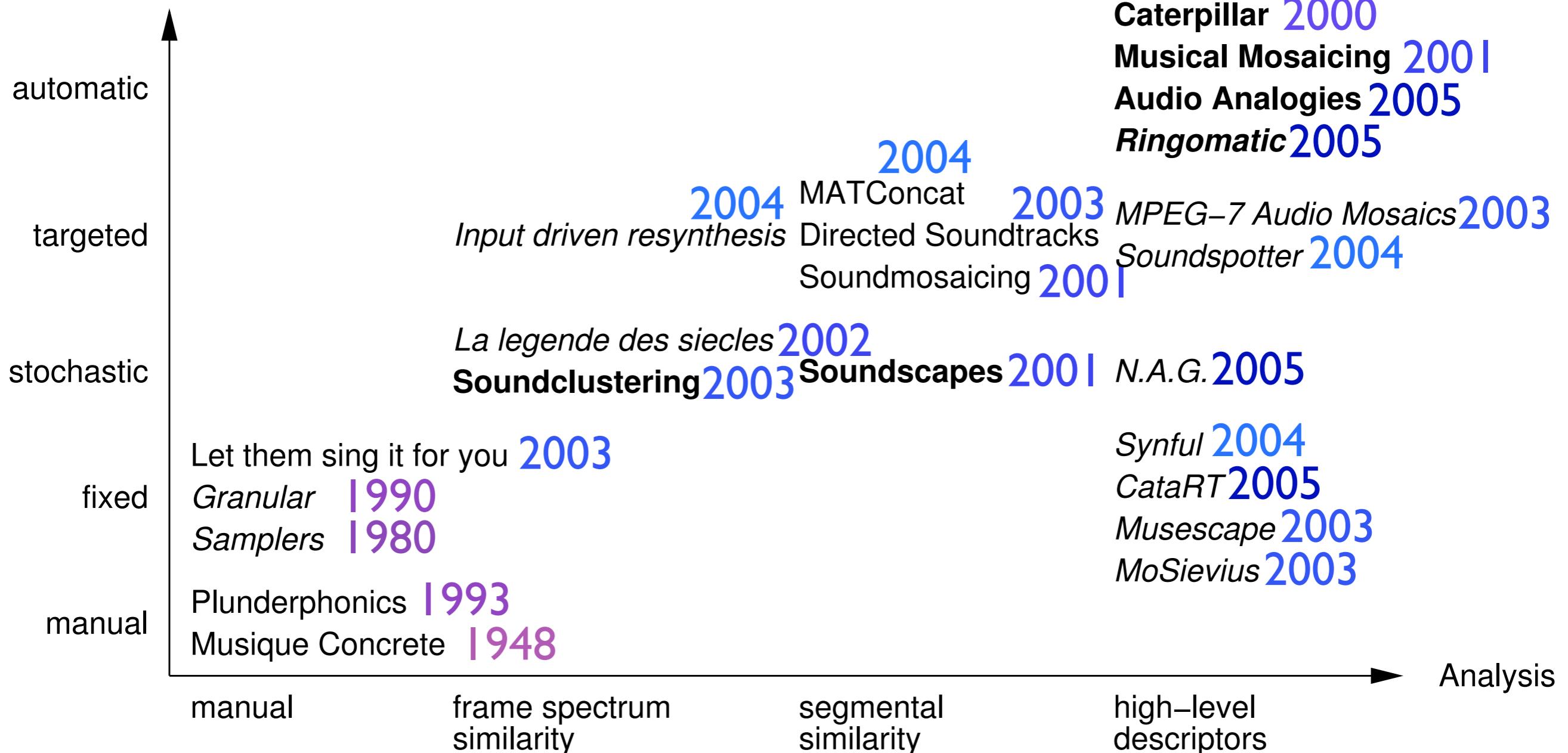


[\[http://www.medienkunstnetz.de/works/williams-mix\]](http://www.medienkunstnetz.de/works/williams-mix)

# Related Work up to 2005

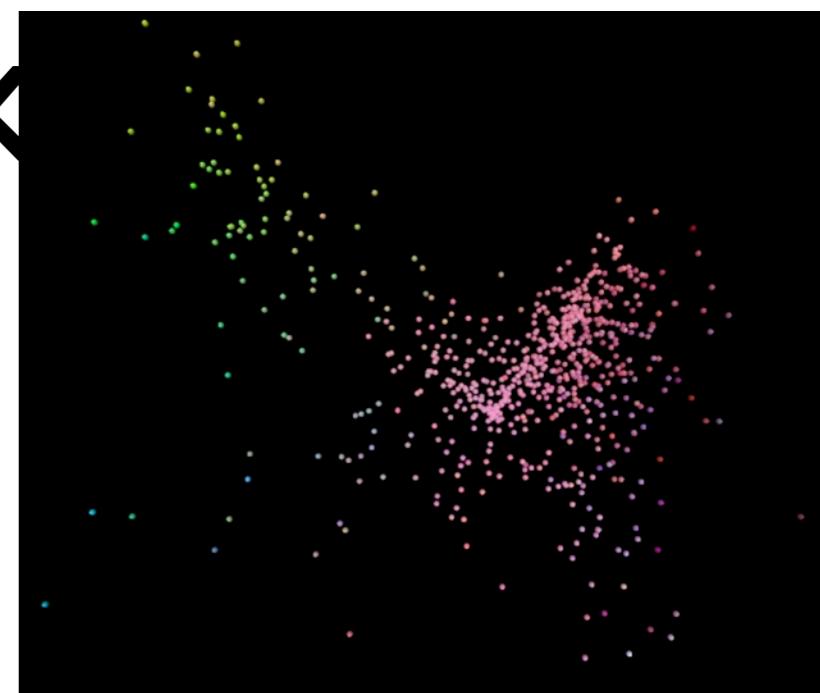
# [Schwarz, JNMR 2006]

## Selection



# Current Related Work

- *TimbreID* (William Brent) is a collection of PD externals that allow descriptor analysis, corpus-based concatenative synthesis and CataRT-style 2D interaction
- *Extending voice-driven synthesis to audio mosaicing* (Jordi Janer, Maarten de Boer): a system for controlling audio mosaicing with a voice signal
- *Mused: Navigating the Personal Sample Library* (Graham Coleman): a system for sample-based music composition
- *ScrambledHacks* (2006): performance system for spectral lookup alongside ganged music video concatenation



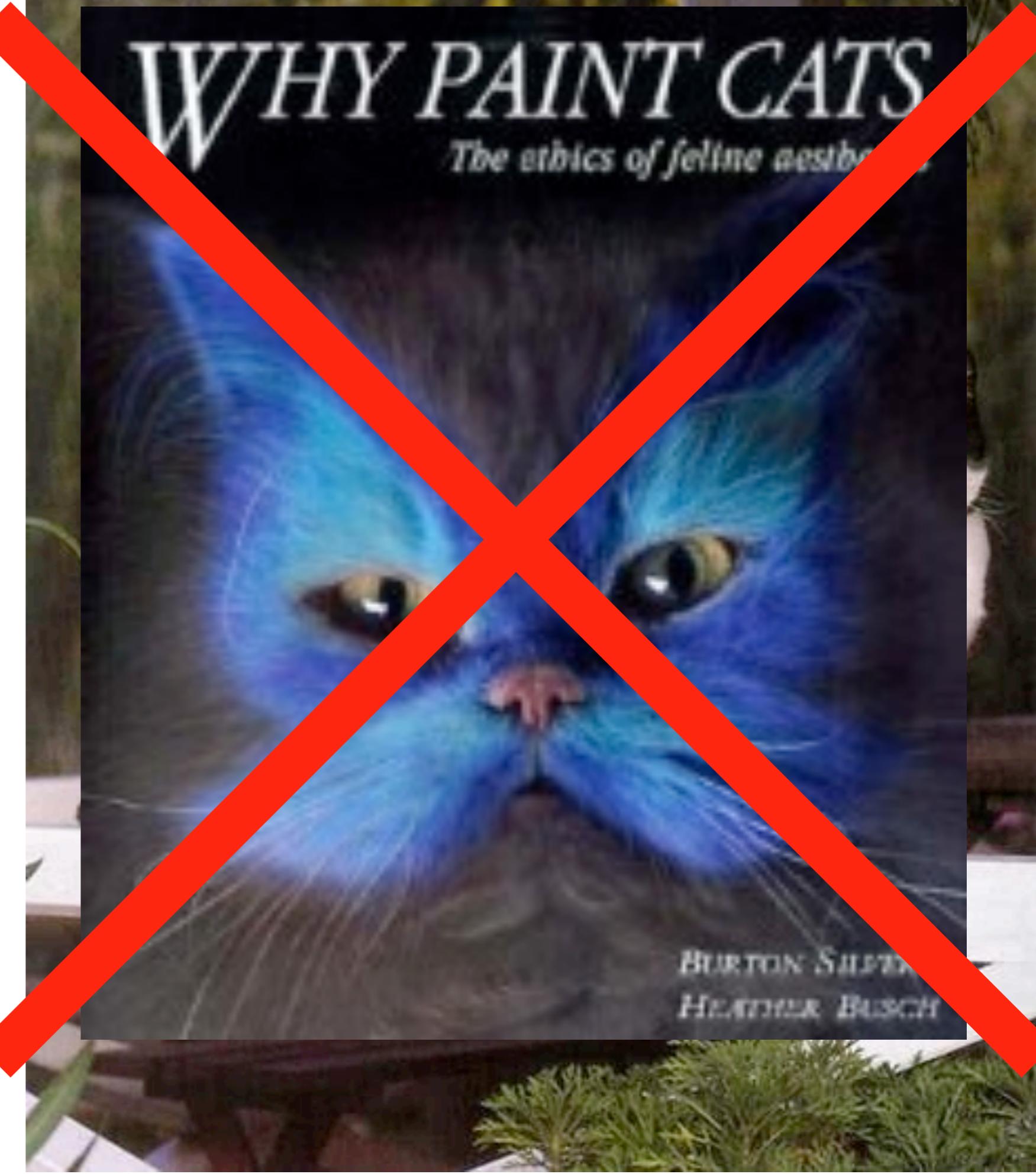
# CataRT Introduction

- flexible testbed to experiment real-time corpus-based concatenative synthesis:  
**CataRT**
- realisation of CBCS in real-time
  - patch for Max/MSP with FTM, Gabor, MnM by Norbert Schnell et al. from **<http://ftm.ircam.fr>**
  - released as Free Software under GPL at **<http://imtr.ircam.fr>**
  - mailing list **concat** on **<http://list.ircam.fr>**
  - modular MVC architecture:

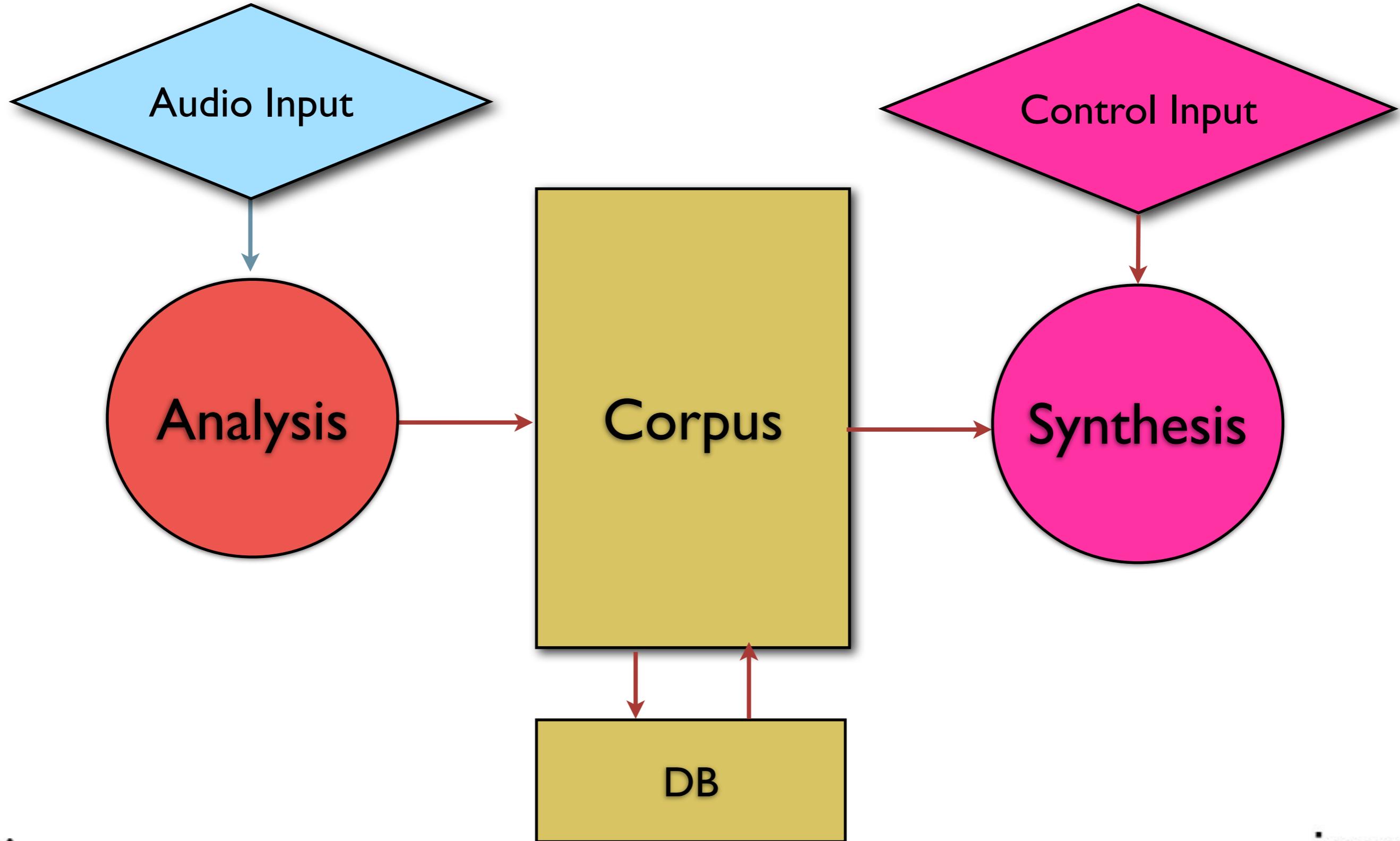


~~CatArt (?)~~

**CataRT**



# CataRT Overview



# Analysis

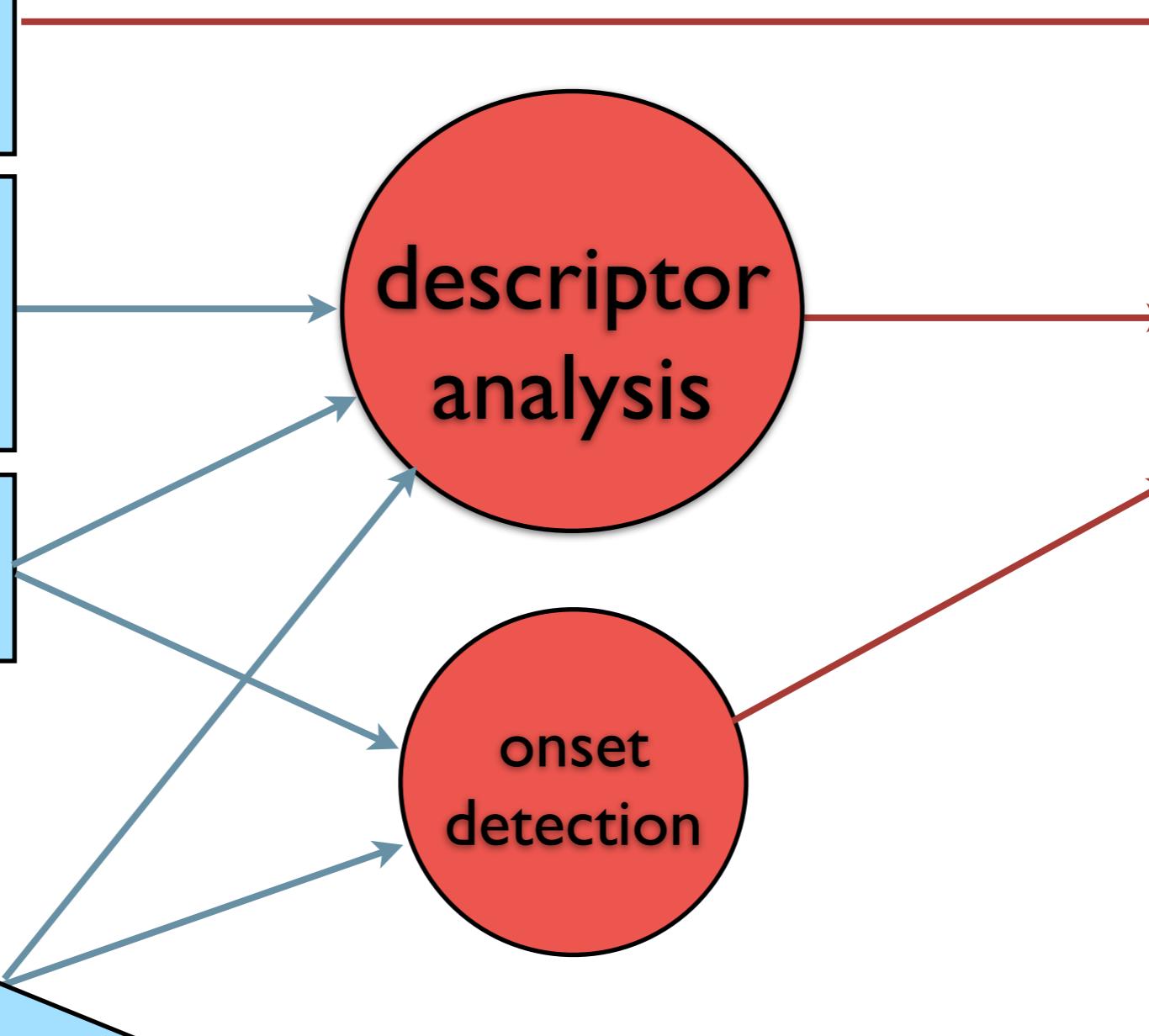
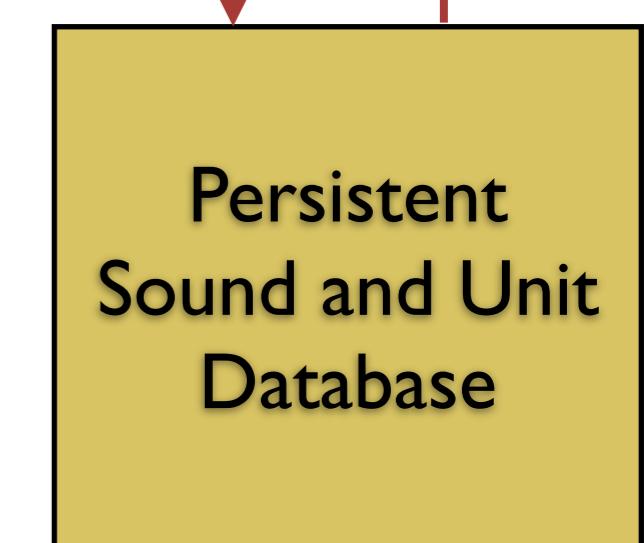
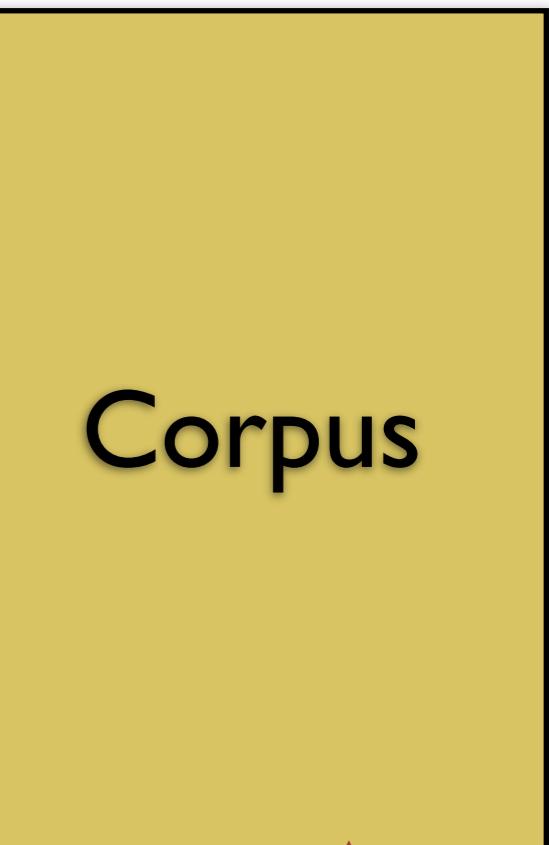
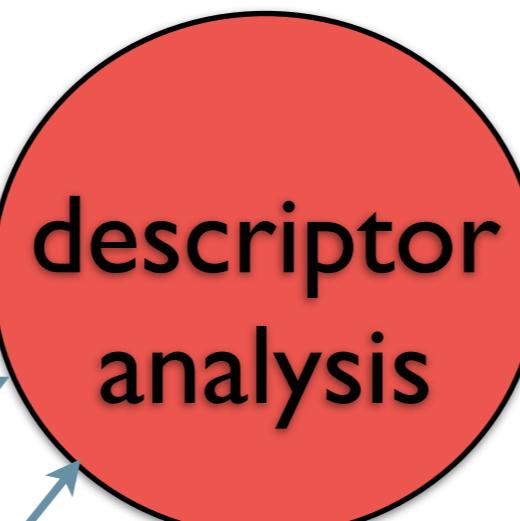
## Audio Input

Soundfile  
+markers  
+descriptors

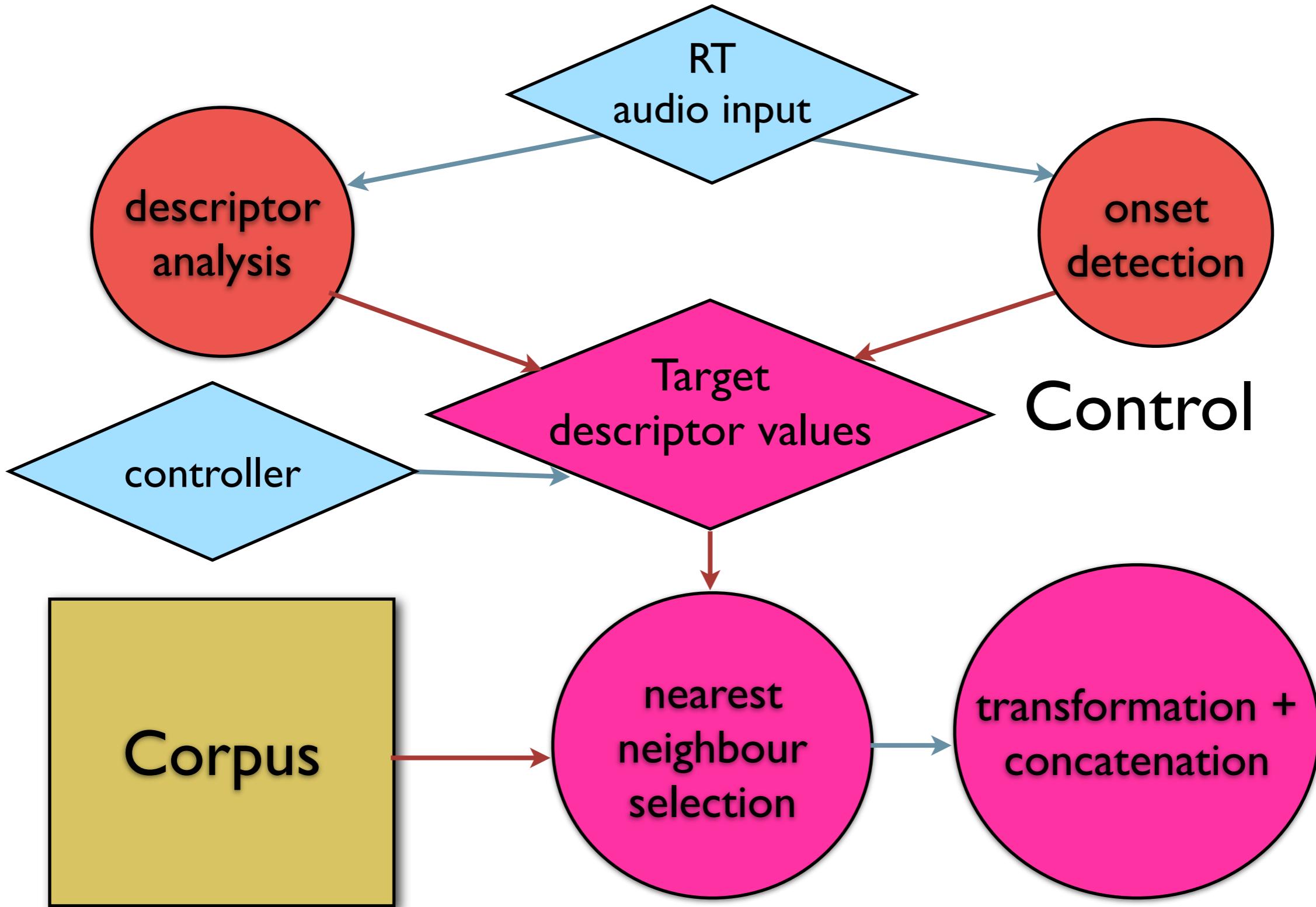
Soundfile  
+grain size  
or markers

Soundfile

RT audio input



# Synthesis



# Architecture

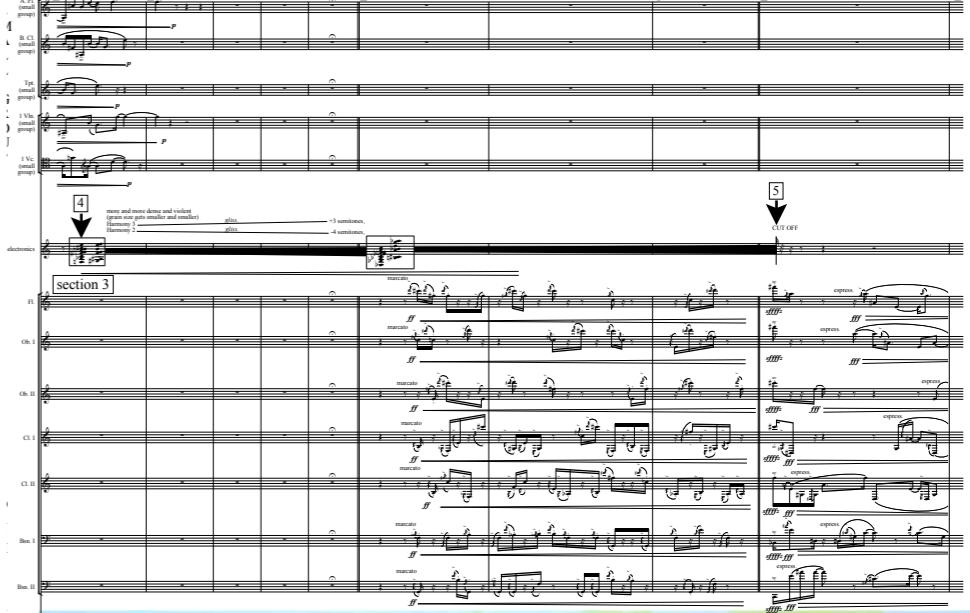
- one catart.data per corpus
- one catart.import for segmentation and analysis
- any number of catart.data.proxy to access data
- any number of catart.lcd for display and control
- any number of catart.selection per corpus
- any number of catart.synthesis per selection or per corpus



# Composers and Projects using CataRT

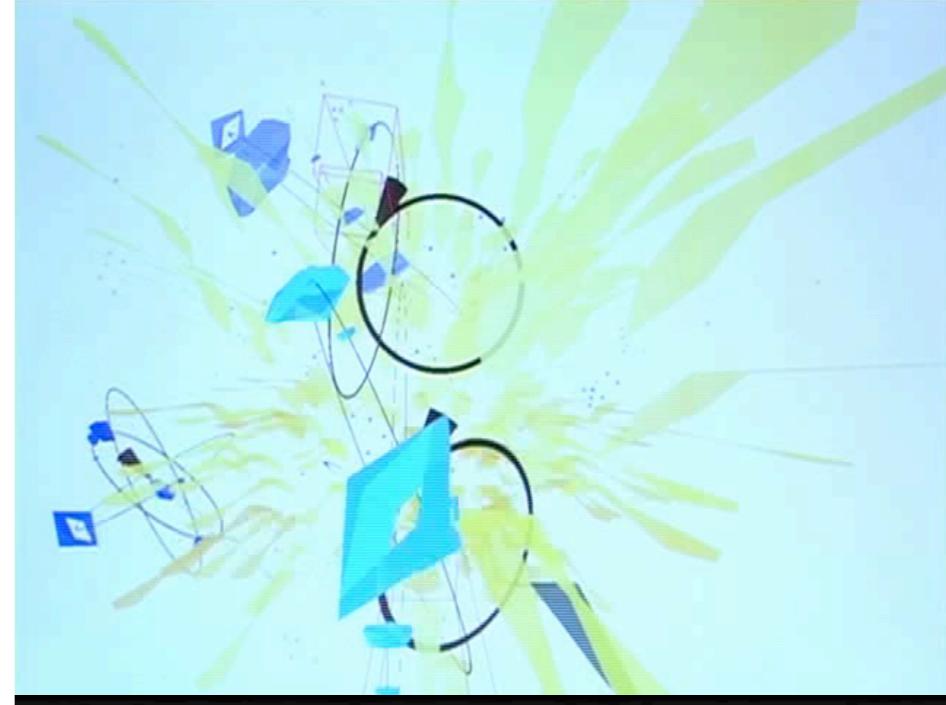
## ■ Sound design and composition

Luis Naõn, Hans Tutschku, Matthew Burtner,  
Sebastien Roux, Hector Parra, Roque Rivas,  
Ben Hackbart



## ■ Installation

*Plumage* (project *Enigmes* about the navigable score, Roland Cahen), Pierre Jodlowski,  
Cécile Babiole, Franck Leibovici



## ■ Live electro-acoustic music

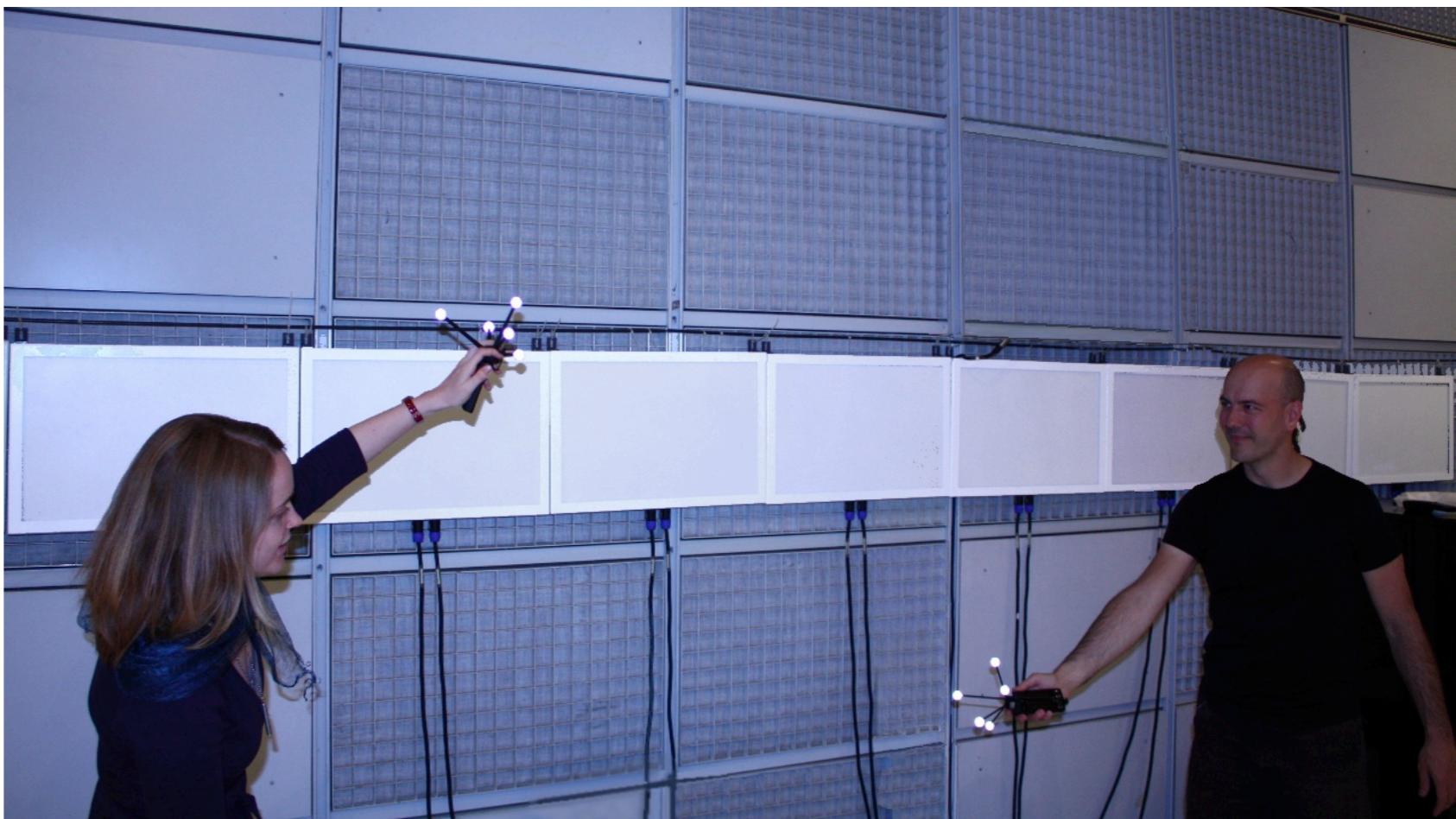
Dai Fujikura, Stefano Gervasoni, Miguel Angel Ortiz-Pérez, Sam Britton, Aaron Einbond, Bruno Ruviaro, Christopher Trapani, Marc Vitoria, Eric Maestri, *theconcatenator*



## ■ Examples: [myspace.com/catartsoftware](http://myspace.com/catartsoftware)

# Installation *GrainStick*

- “Rainstick” gestural control metaphor
- Demo of *SAME* (*Sound And Music for Everyone Everyday Everywhere Every way*) EU project
  - Composition of sounds and ambiances by Pierre Jodlowski
  - WFS spatialisation and Motion Tracking by Grace Leslie and the Room Acoustics team
  - Gesture analysis by Bruno Zamborlin and Diemo Schwarz



# Grainstick Example I

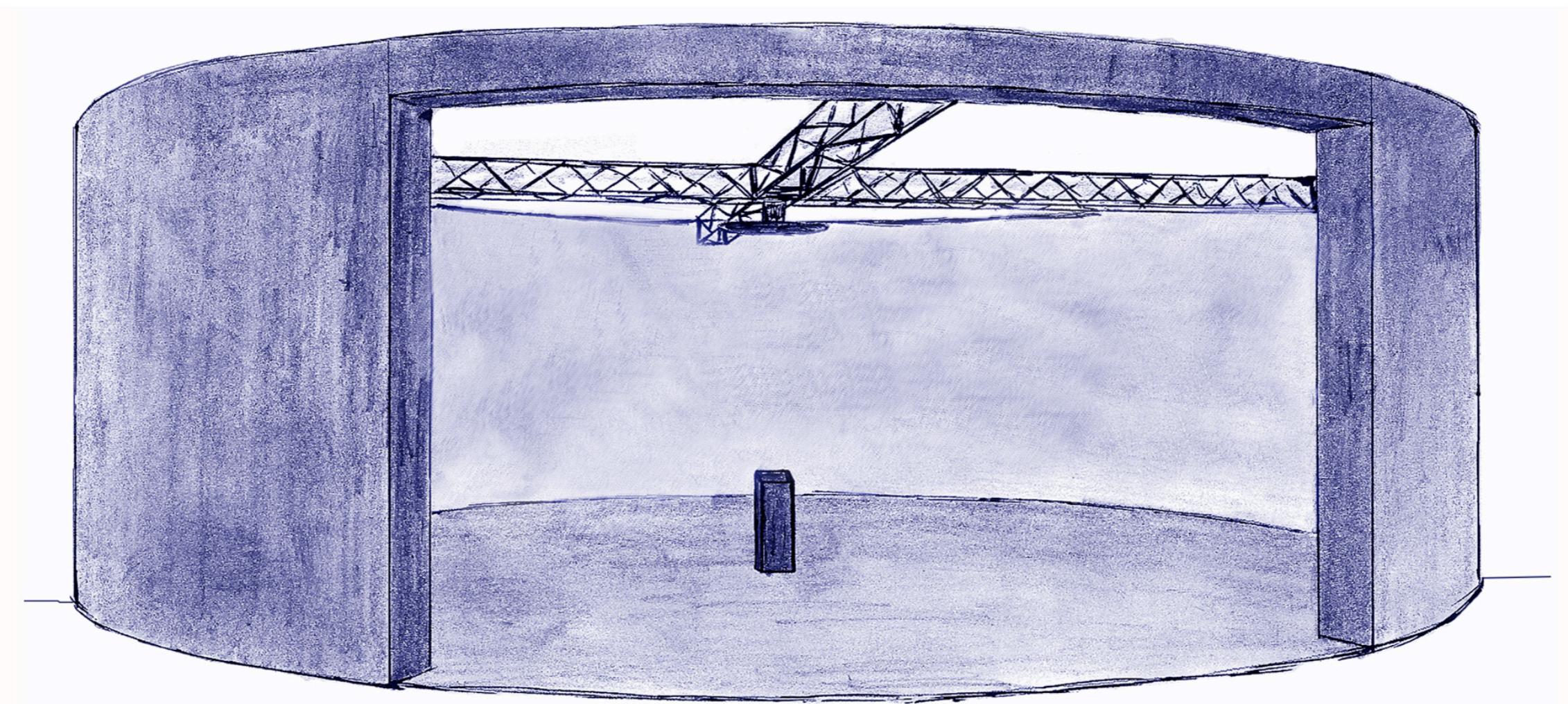


# *Grainstick Example 2*



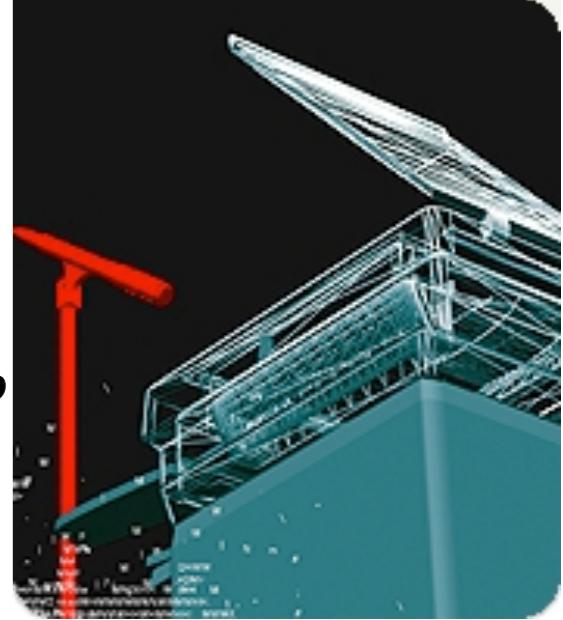
# Grainstick Installations

- Prototype: Agora Festival 2009, Ircam, Paris
- Public installation: 6. June 2010, Cité des Sciences, Paris
  - including video projection, more collaborative elements, several universes



# Installation Xe-Rocks

- Turning photocopiers into musical instruments, by video and sound artist Cécile Babiole
- On show at the ECM Gantner, Bourgogne

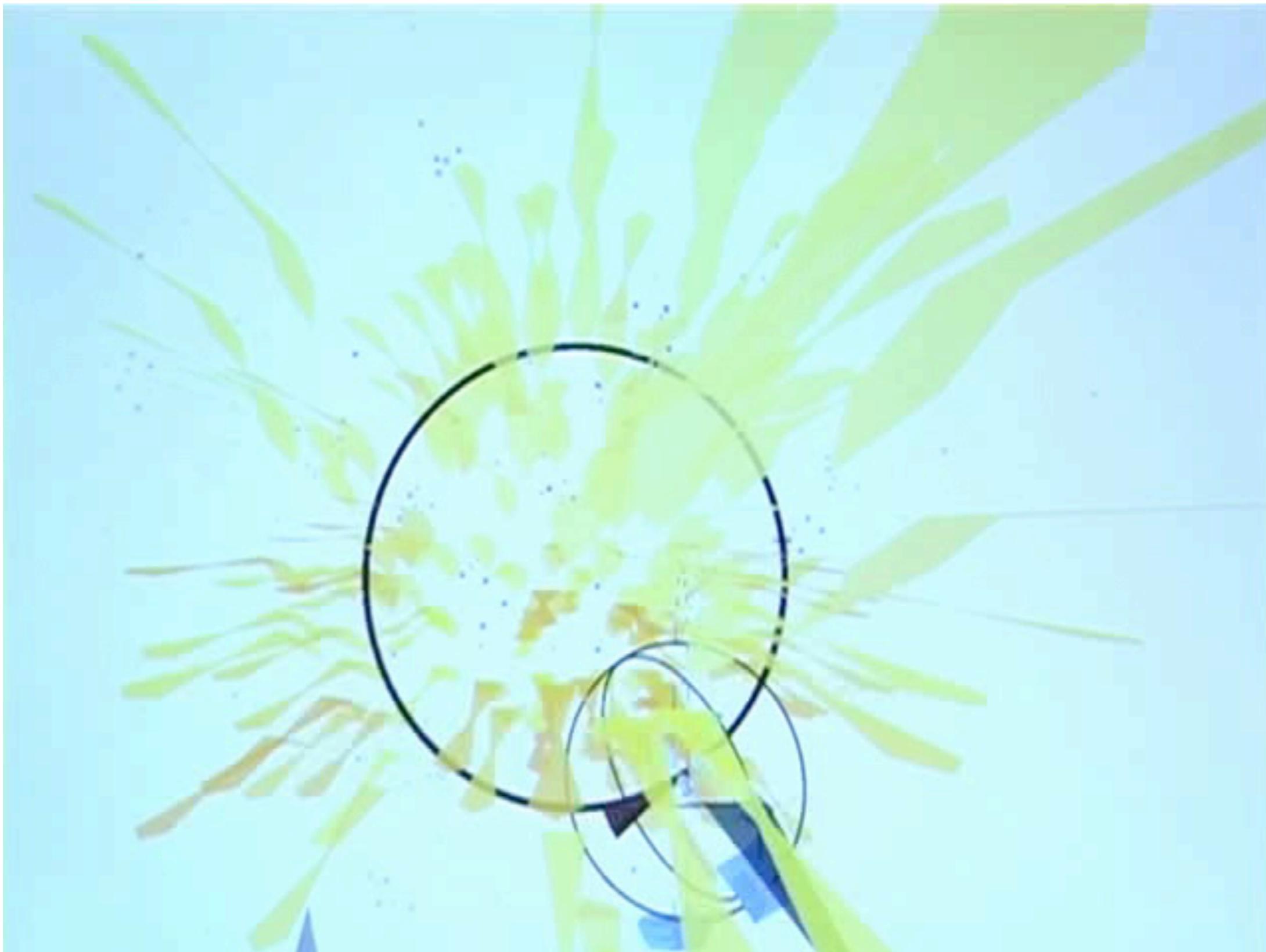


# Installation *Plumage*

- Collaboration with national design school ENSCI led by Roland Cahen, Yoan Ollivier, Benjamin Wulf (ENSCI), Christian Jacquemin, Rami Ajaj (LIMSI), Diemo Schwarz (Ircam)
  - within the project *ENIGMES* about the navigable score
  - 3D interface using *Virtual Choreographer*  
**<http://virchor.sourceforge.net>**



# Plumage



# Plumage



# Plumage



# Live Recording the Corpus

- Corpus-based improvisation with live sound input
  - Diemo Schwarz with Etienne Brunet
- Live Algorithms for Music (LAM) concerts:
  - Improvisation of George Lewis, Evan Parker, Sam Britton, Diemo Schwarz and others
  - *Rien du tout* by Sam Britton, Diemo Schwarz





# Electro–Acoustic Music (I)

- *Whisper Not* by Stefano Gervasoni for viola and electronics, computer music realization by Thomas Goepfer
  - “response” of CataRT to the instrument
  - morphing between corpora of pizzicato viola and water-drops

Interaction with pre-recorded sound,  
interpolation, rearranging, navigation



# Electro–Acoustic Music (2)

- *swarming essence* by Dai Fujikura for orchestra and electronics, computer music realization by Manuel Poletti
- harmonic selection of specially composed small instrument group and extended playing style
- corpus-based orchestration, separate treatment

## Re-orchestration, rearranging, navigation

The image shows a musical score for 'electronics'. It features a single staff with a treble clef and a key signature of one sharp. A large black arrow points downwards from a box containing the number '4'. Below the staff, there are two horizontal lines labeled 'Harmony 3' and 'Harmony 2'. Above these lines, text indicates: 'more and more dense and violent (grain size gets smaller and smaller)'. To the right of the staff, a glissando line starts at 'Harmony 3' and ends at 'Harmony 2', with the text 'gliss.' above it. Further to the right, another glissando line starts at 'Harmony 2' and ends at a lower pitch, with the text 'gliss.' below it. Above this second glissando line, the text '+3 semitones,' is written. Below it, the text '-4 semitones,' is written. The score consists of several short vertical bars of notes on the staff, with a long continuous bar spanning most of the width of the page. The notes are primarily black dots, with some having small stems or being grouped together. The overall style is minimalist and abstract.

3  
 18  
 4  
 = 60  
 ca. 20 - 21 sec.  
 3  
 4  
 = 102  
 3  
 8

A. Fl. (small group)  
 B. Cl. (small group)  
 Tpt. (small group)  
 1 Vln. (small group)  
 1 Vc. (small group)

more and more dense and violent  
 (grain size gets smaller and smaller)  
 Harmony 3 ————— gliss. +3 semitones,  
 Harmony 2 ————— gliss. -4 semitones,

section 3

Fl.  
 Ob. I  
 Ob. II  
 Cl. I

# Live Control and Composition

- *Beside Oneself*, Aaron Einbond, 2008 for viola and electronics:
  - real time control of CataRT from audio analysis of the viola
- *What the blind see* 2009 for small ensemble and electronics
  - real time control of CataRT from audio analysis of the viola
  - corpus-based “orchestration” or transcription
  - texture example:
    - I. Rain on leaves
    - 2. CataRT resynthesis with extended technique instrument sounds



# Aaron Einbond – *What the blind see*

I. snow melting on a metal roof

28 3. manually edited transcription

2. CataRT resynthesis with instrument sounds

4. live reading by ensemble

**Alto:** C10 *a tempo*, 193. Dynamics: >*pp*, *ppp*. Performance: *arco*, *gliss.* (main), IV.

**Cl.B. en Sib:** Dynamics: *f*, *sfz*, *sfz*, *p*, *f*, *sfz*, *sfz*. Instructions: bruit des clefs : doigtés ad lib.

**Hp.:** SF neige to concatenation C10 *a tempo*. Dynamics: *p*, *pp*, *p*, <*sfz*, *p*. Articulations: étouffé avec papier sempre, paume, ongles.

**Pno.:** Dynamics: *p* plectre, *sfz*, *pp*. Articulations: *s* *vib*.

**Vib.:** Vib. superball, *p*, *sempre*, *vib*, *sfz*.

# Bruno Ruviaro – *Intellectual Improperity 0.6*

- Using *Catork*, a CataRT-based system for electronic music composition for laptop orchestras

**<http://www.brunoruviaro.com/catork>**

- Premiered by the Stanford Laptop Orchestra (SLOrk) April, 2010 (chamber version with six laptops), and June (full ensemble version)



# Gestural Control



# New Concepts for Musical Applications

- Re-arranging units by other rules than temporal order
- Composition = Navigation through the sound space of heterogeneous sound databases
  - exploit richness of detail of recorded sound
  - efficient control by perceptually and musically meaningful descriptors
- Interaction with self-recorded sound: sound of a musician is available for interaction beyond simple repetition
- Cross-selection and interpolation: apply sound characteristics from one corpus to another, morphing between corpora
- Orchestration and re-orchestration: matching a mass of sounds to a harmonic or sonic target while retaining precise control over the result



# Current and Future Directions

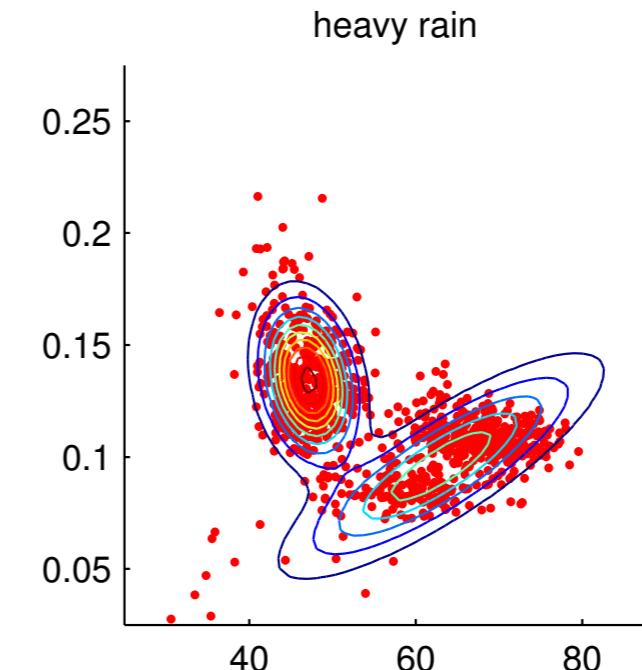
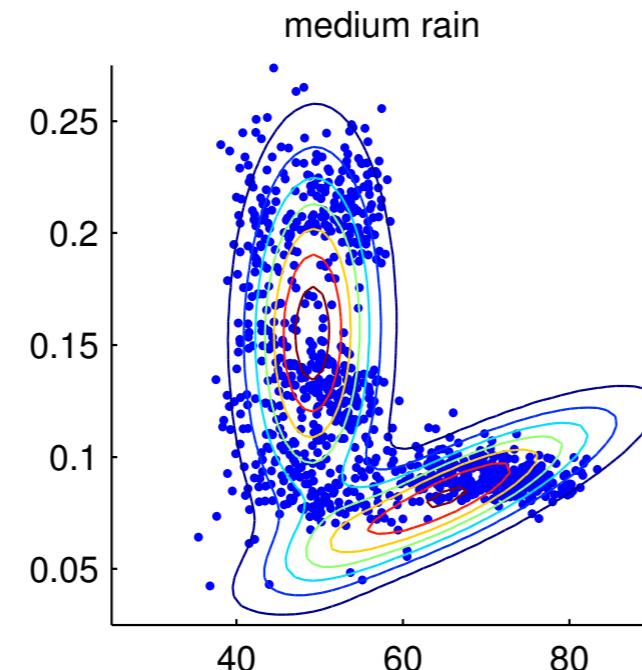
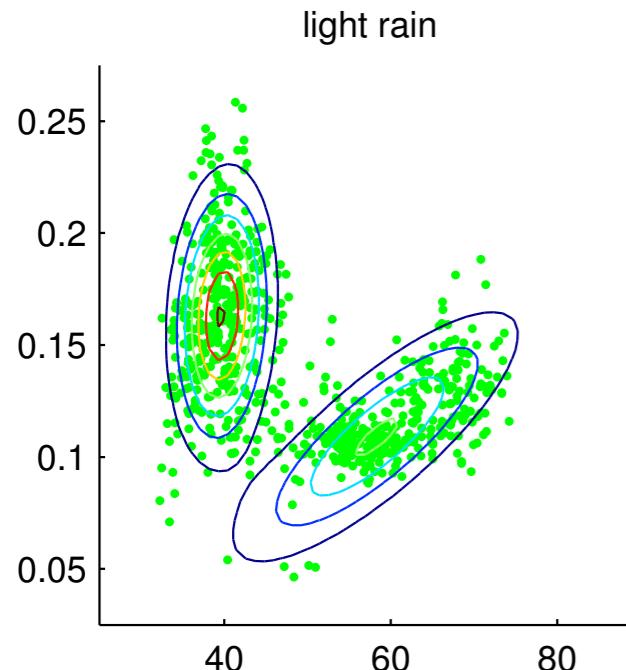
## Interface

- multi-dimensional scaling by mass–spring–damper model

- uniformisation of density

## Sound texture synthesis

## Modeling of transitions and articulations



# Acknowledgements

- CataRT is based on FTM&Co by Norbert Schnell et al.
- Thanks go to:
  - Alexis Baskind, Julien Bloit, Greg Beller, Miguel Angel Ortiz Pérez
  - Roland Cahen, Yoan Olliver, Benjamin Wulf (ENSCI),
  - Christian Jacquemin, Rami Ajaj (LIMSI)
  - Norbert Schnell, Riccardo Borghesi, Frédéric Bevilacqua, Rémy Muller, Jean-Philippe Lambert (IMTR Team)
  - the French National Agency of Research ANR and the projects *Sample Orchestrator* and *Topophonie*
- Links:
  - CataRT wiki on **imtr.ircam.fr**,
  - mailinglist **concat@ircam.fr** and **ftm@ircam.fr** on <http://lists.ircam.fr>



# Exercise Suggestions

## Adapting CataRT

- Integration in your concert patch
- Adapting to your musical needs/ideas

## Improving CataRT

- Corpus Data
  - soundfile editor (list/delete sounds in corpus)
  - soundset editor (define sound sets, add/remove units)
  - descriptor range viewer/editor (e.g.: exclude units below threshold)

## Analysis

- segmentation editor

## Selection

- constraints: don't repeat unit

## Synthesis

- forced pitch/loudness

- multi-channel output

## Control

- by MIDI notes

- by envelopes, sequencer

- by live sound analysis

