The Extraction of Structure from a Musical Piece

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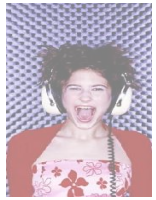
Musical Structure

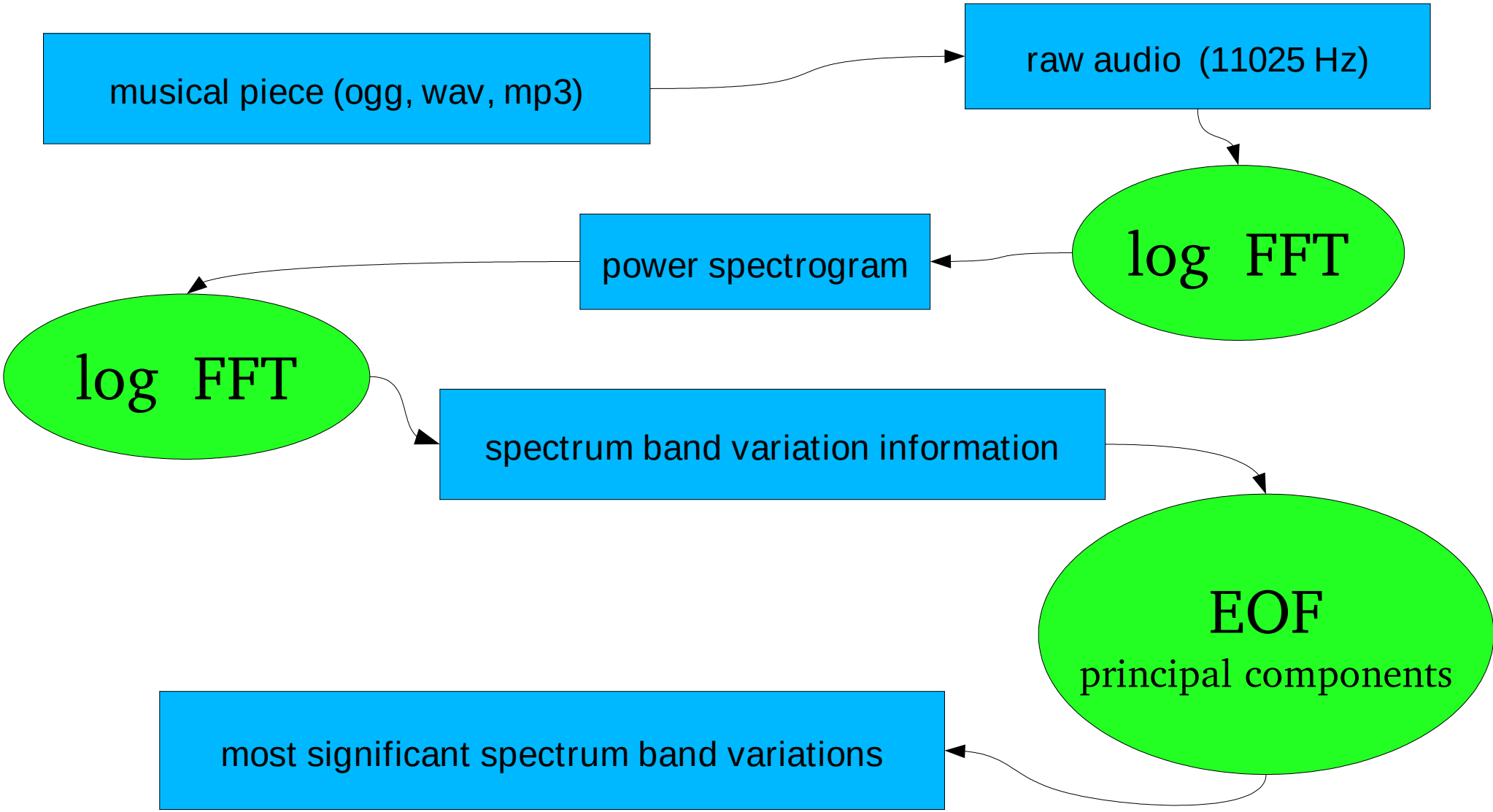
- related to **human perception**
- rather from the **listener's standpoint** than from the **composer's standpoint**



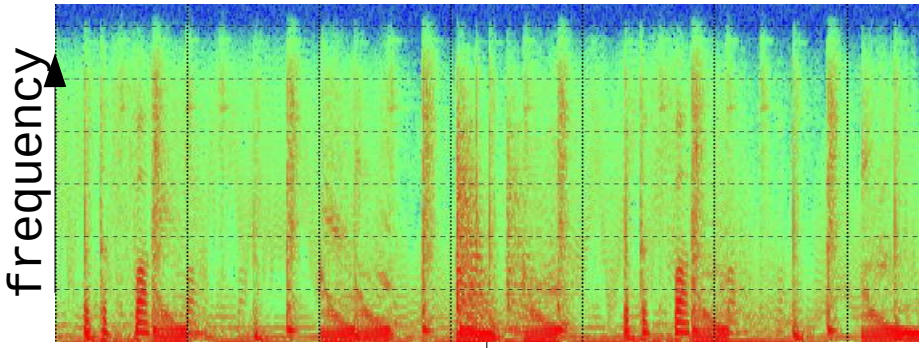
Finding structure

- audio, no MIDI or symbolic information
- *audio descriptors*
- not (yet) limited to one style
- looking for similarity and borders

Most significant spectrum variations



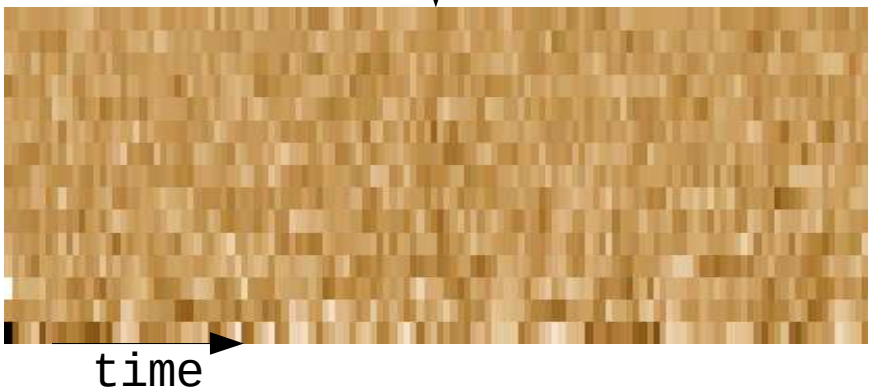
Most significant spectrum variations



spectrogram

100 *feature vectors* per second

PC of “log FFT” of frames from every band



most significant spectrum band variations

about 1 feature vector per second

EOF based on SVD

- Empirical Orthogonal Functions, based on Singular Value Decomposition
- popular in climate research
- type of Principal Component Analysis
- useful for reducing number of dimensions

  while explaining large part of variance

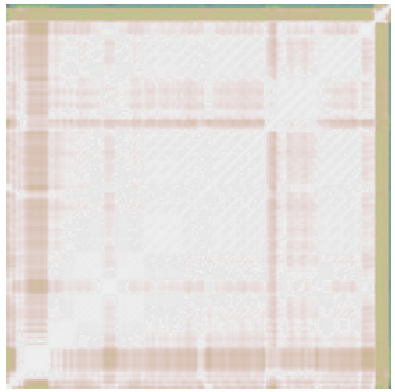
Similarity matrix

J. Foote, 1999

1) the audio descriptors are N-dimensional space

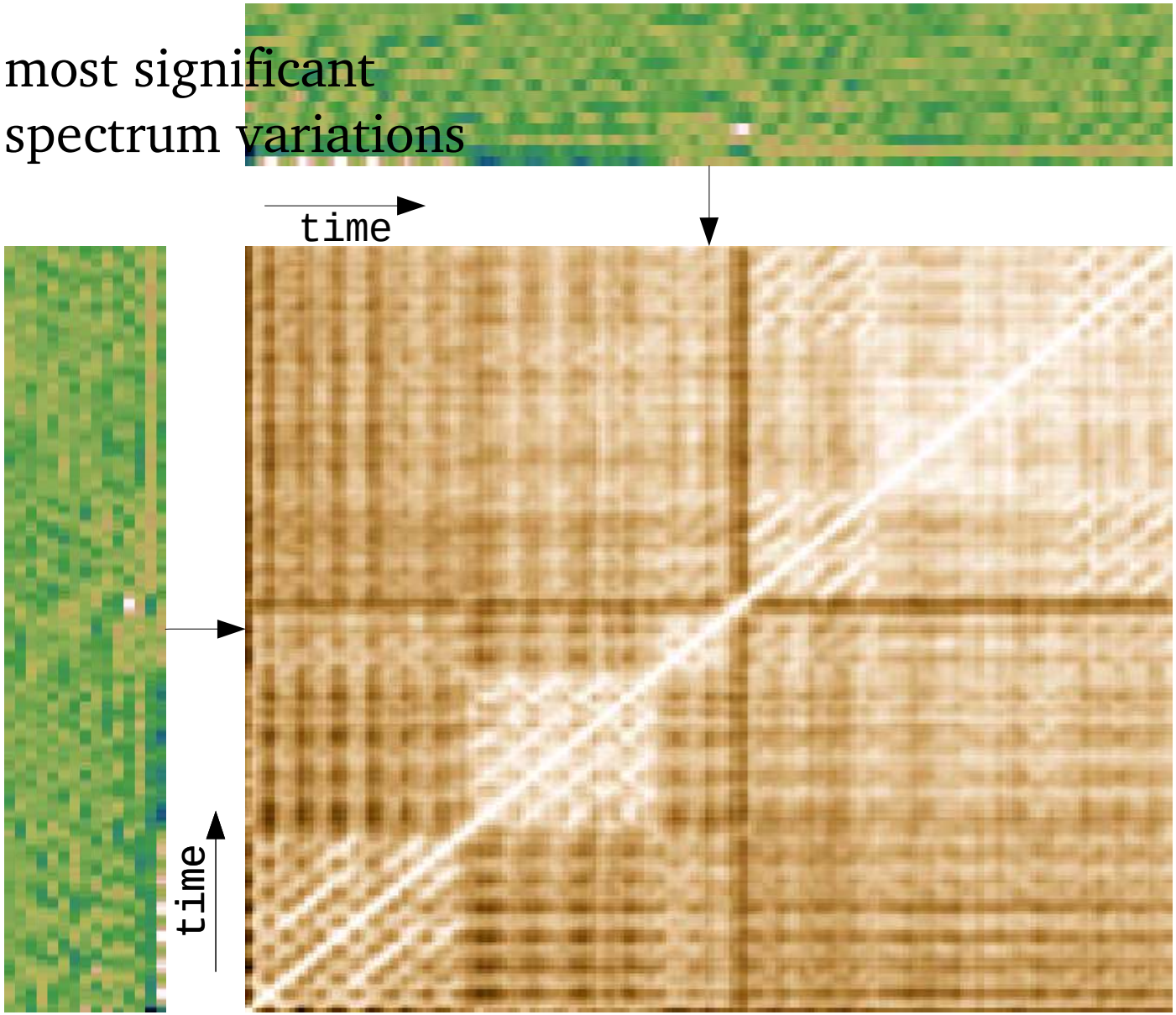
2) calculate mutual distances: distance matrix

3) rescale: similarity matrix



Similarity matrix

most significant
spectrum variations

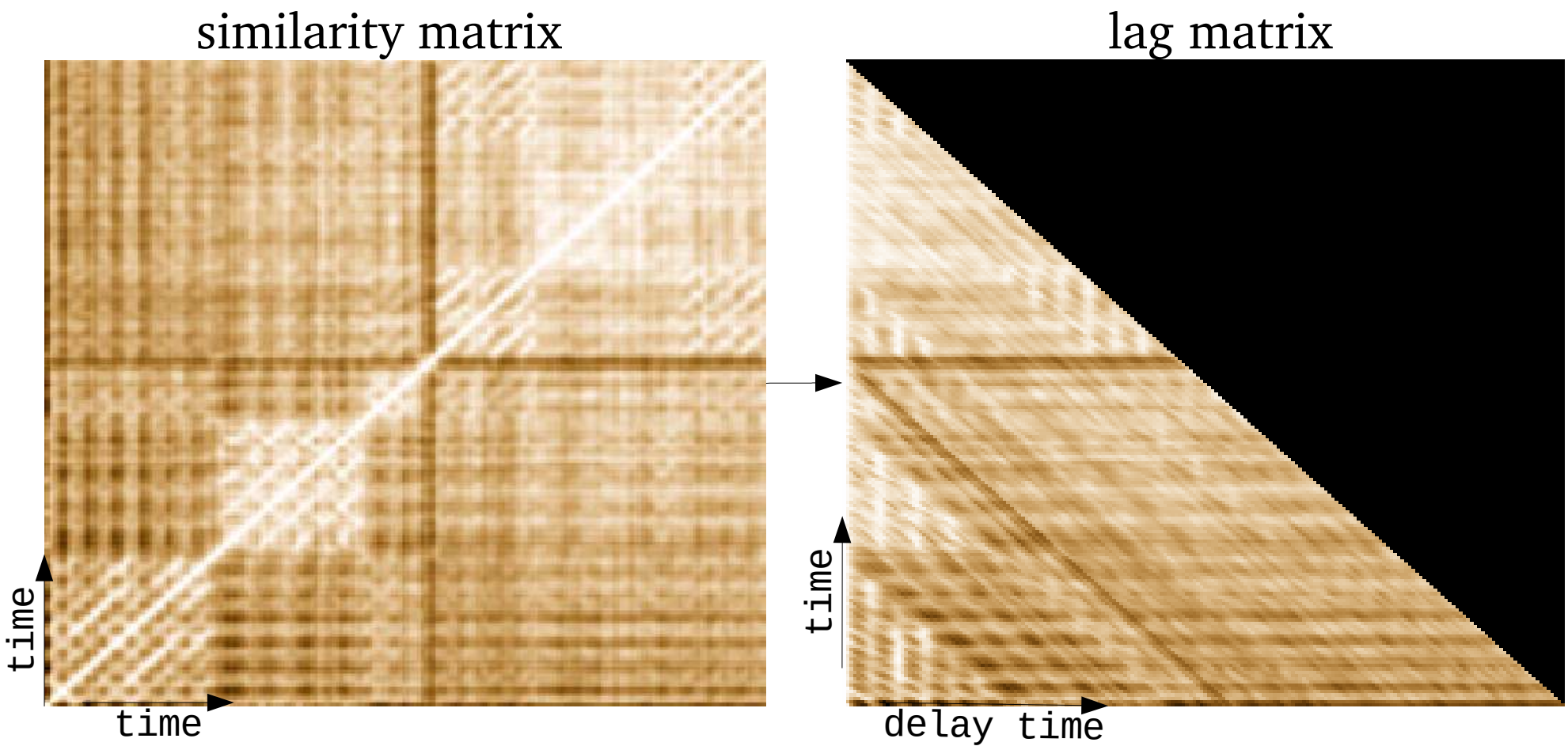


Similarity Matrix

Chardonnay Says
by *Nood/Banana*

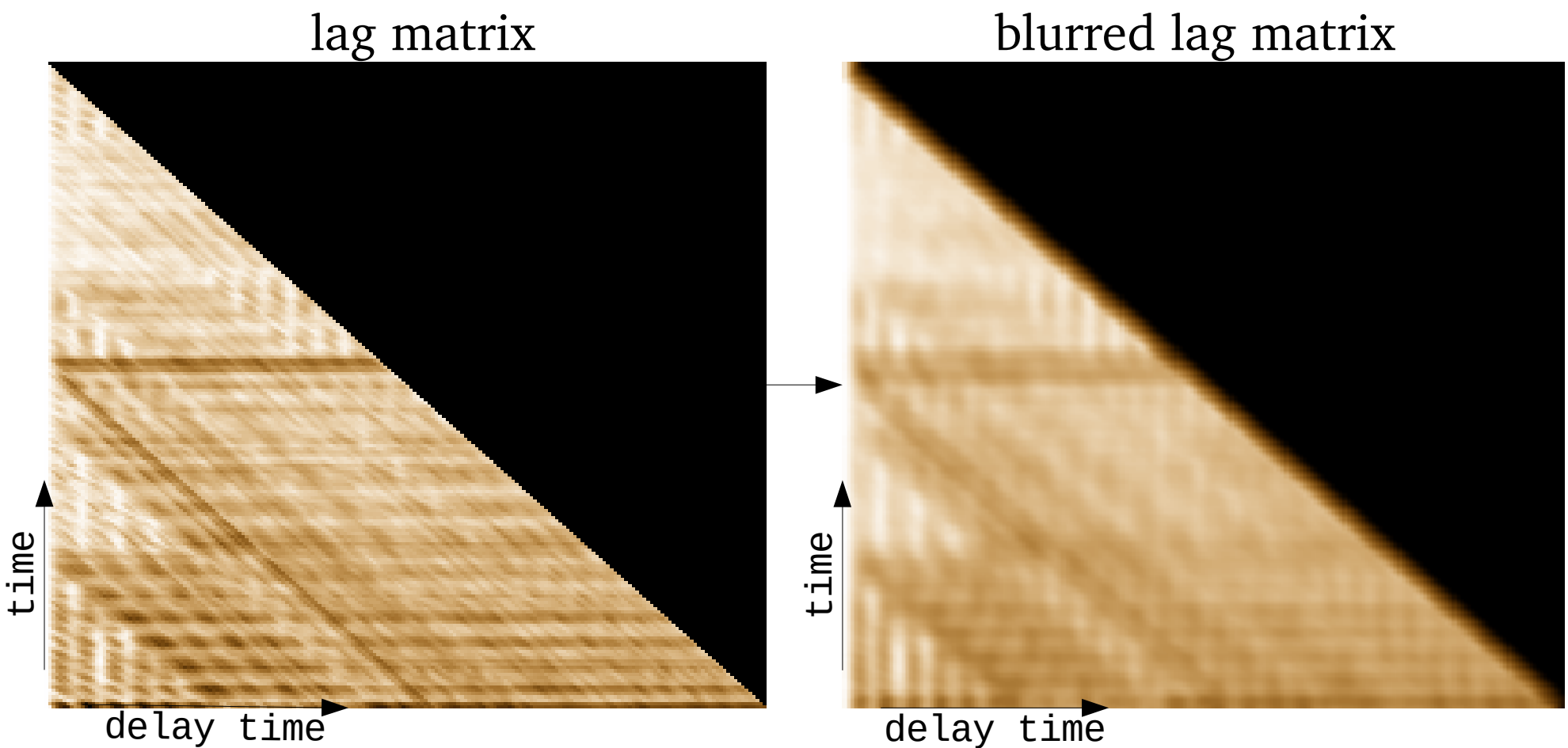
Finding similar parts

step 1: calculate lag matrix



Finding similar parts

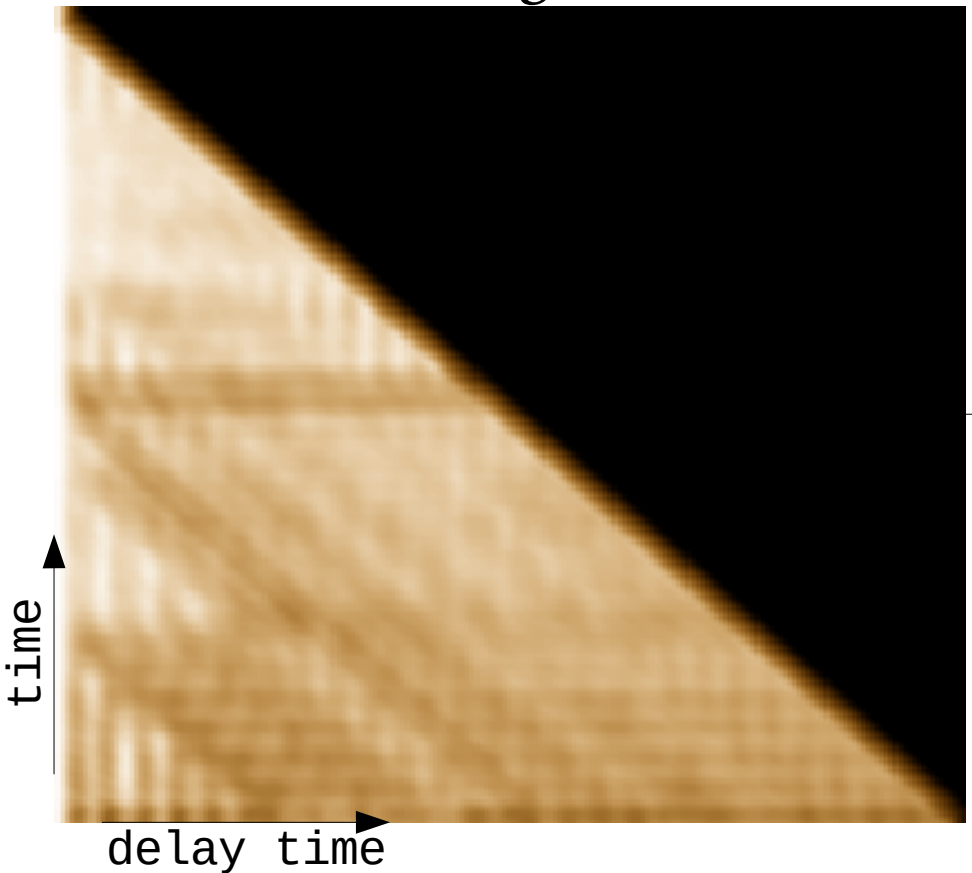
step 2: apply 2D FIR filter to blur



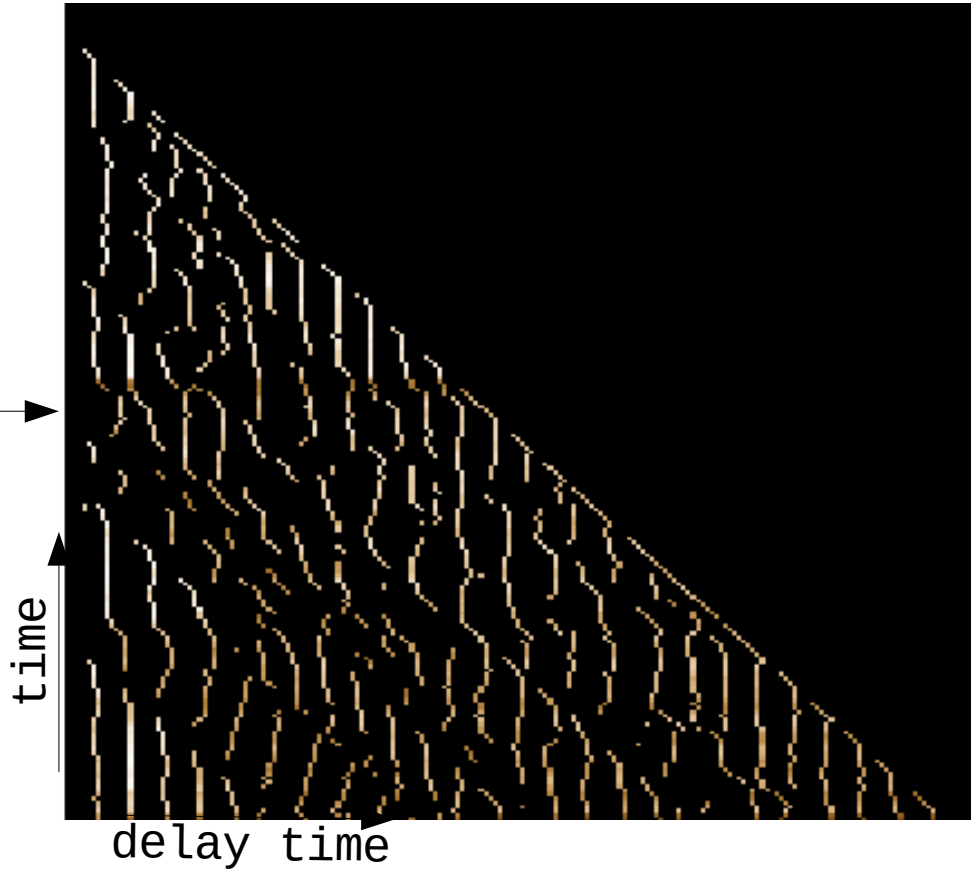
Finding similar parts

step 3: find vertical local maxima

blurred lag matrix



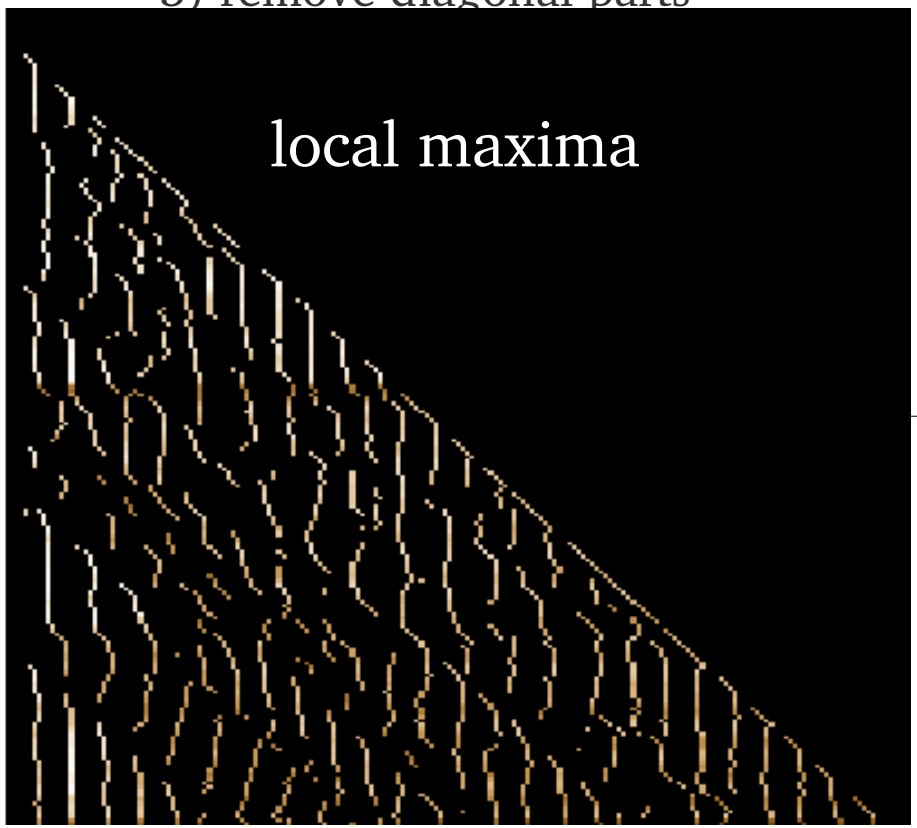
its local maxima
(values from non-blurred matrix)

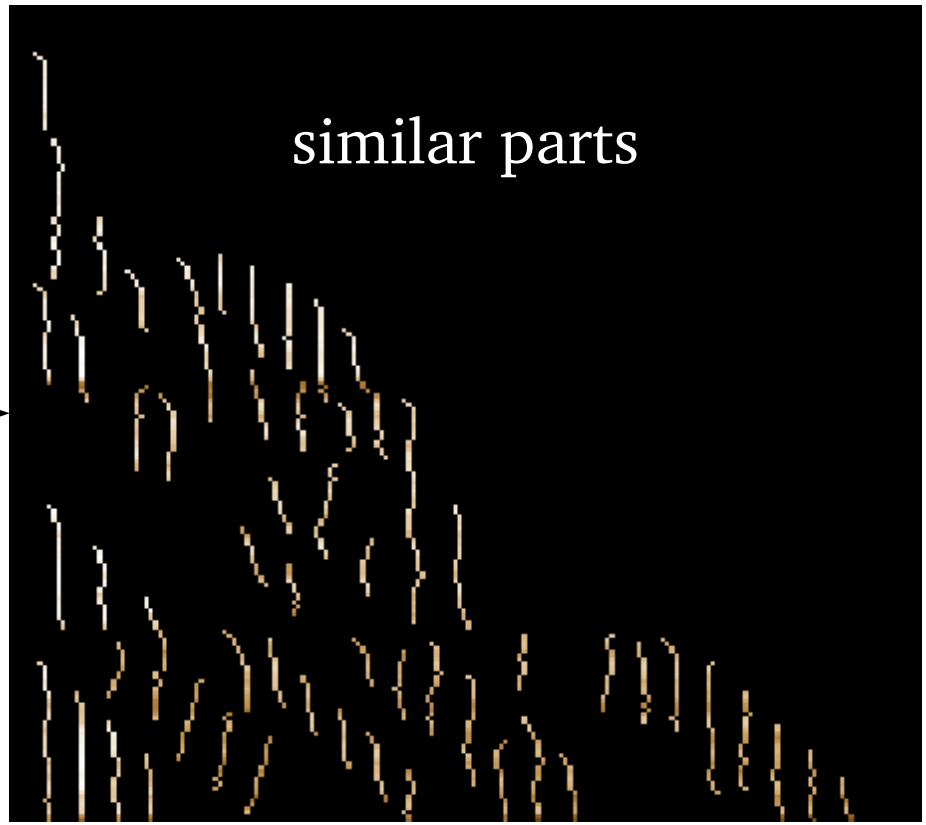


Finding similar parts

step 4: post-processing

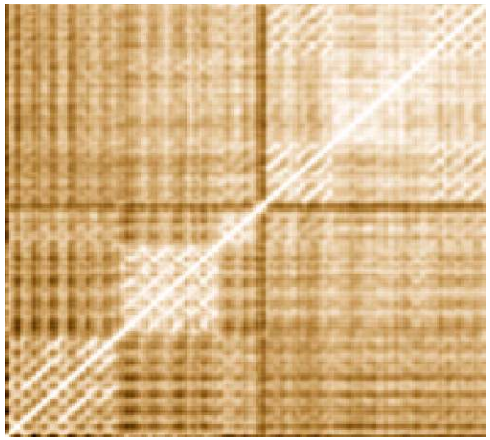
0) forget first column (diagonal of similarity matrix)
1) localize sufficiently long contiguous parts
2) remove overlaps
3) remove diagonal parts



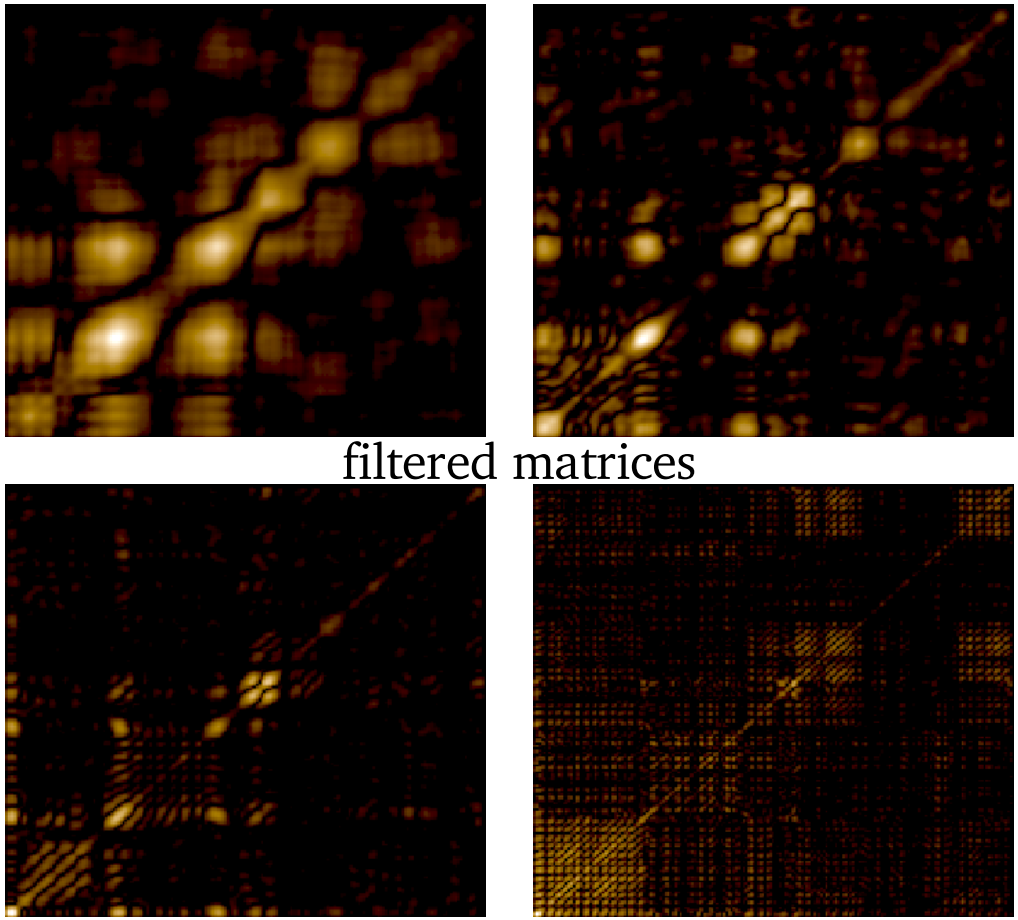


Finding borders

step 1: convolution, kernels of different sizes



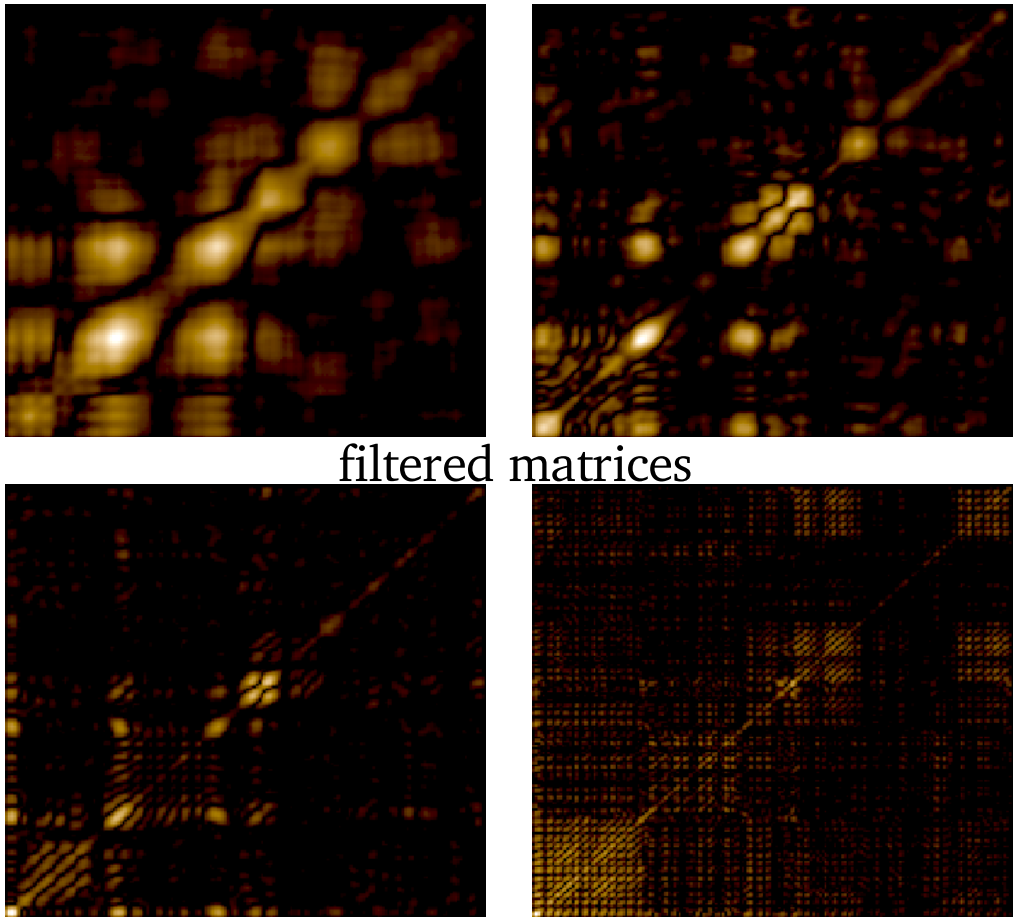
similarity matrix

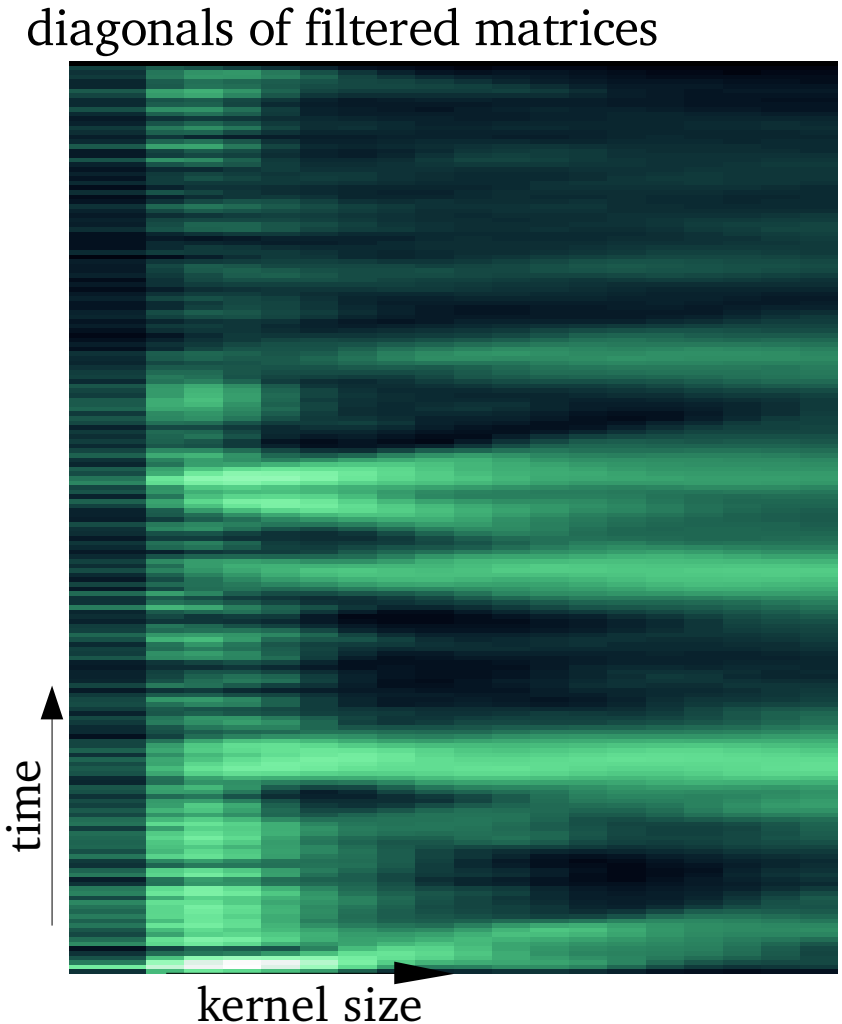


filtered matrices

Finding borders

step 2: diagonals => columns

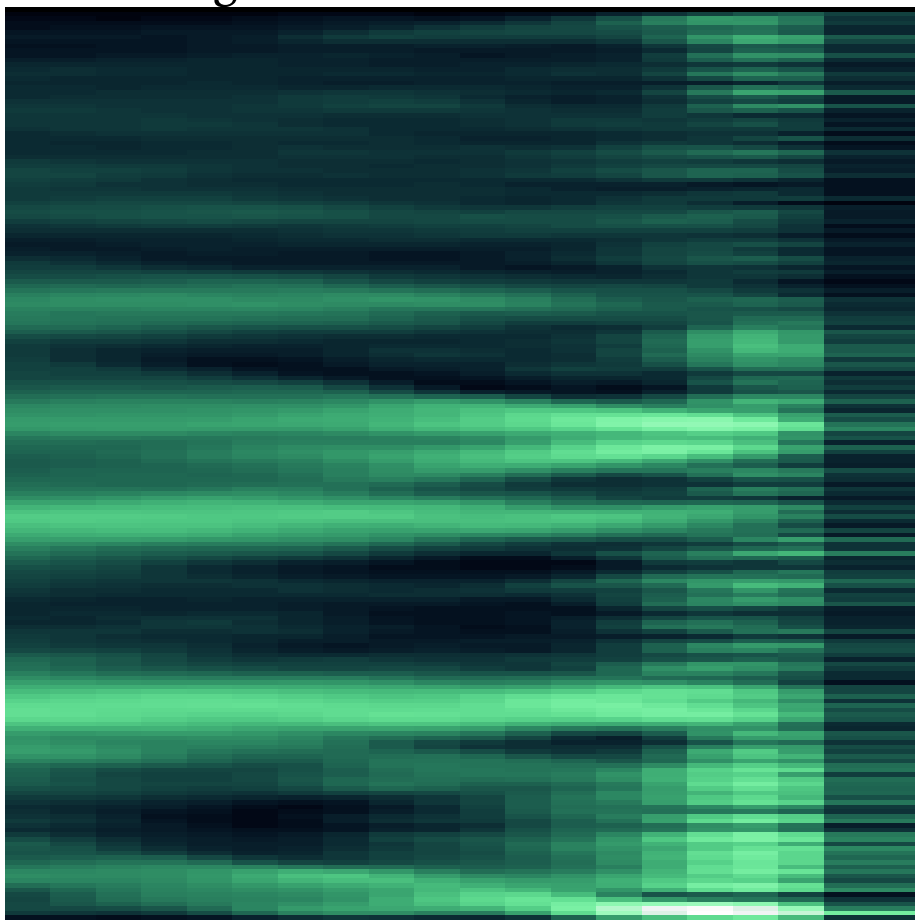




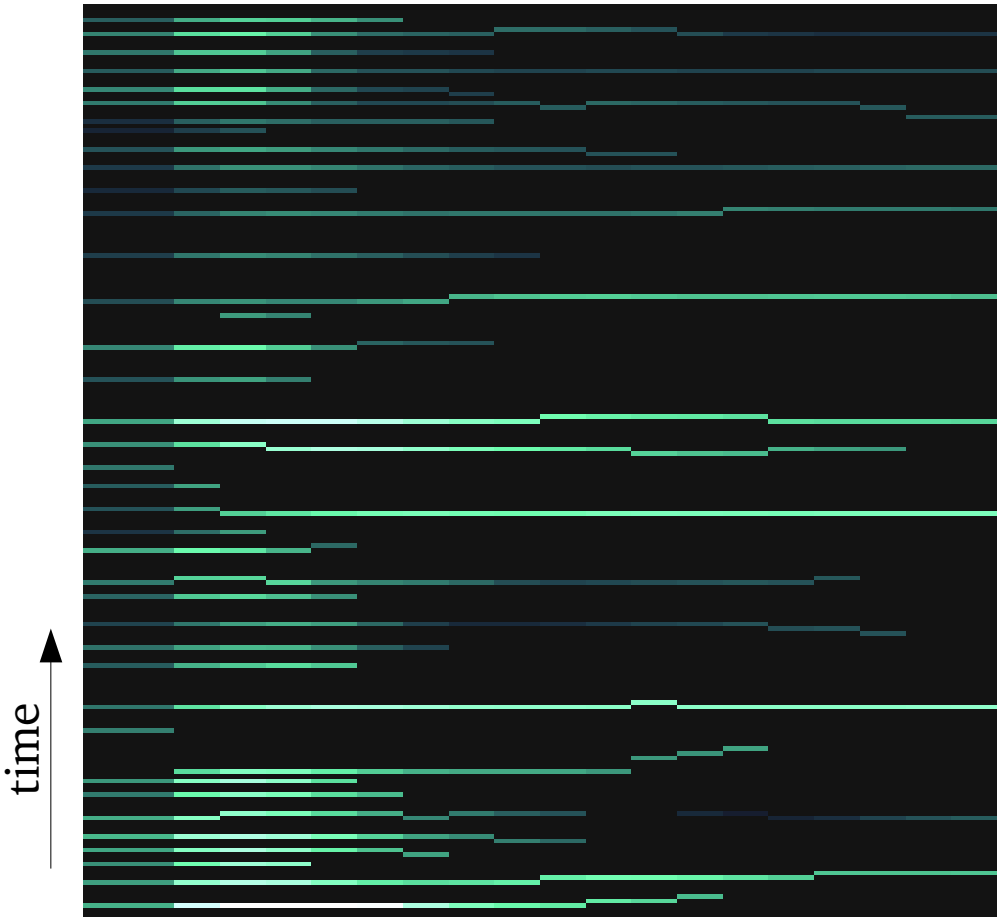
Finding borders

step 3: find local maxima in columns

diagonals of filtered matrices



local maxima



Finding borders

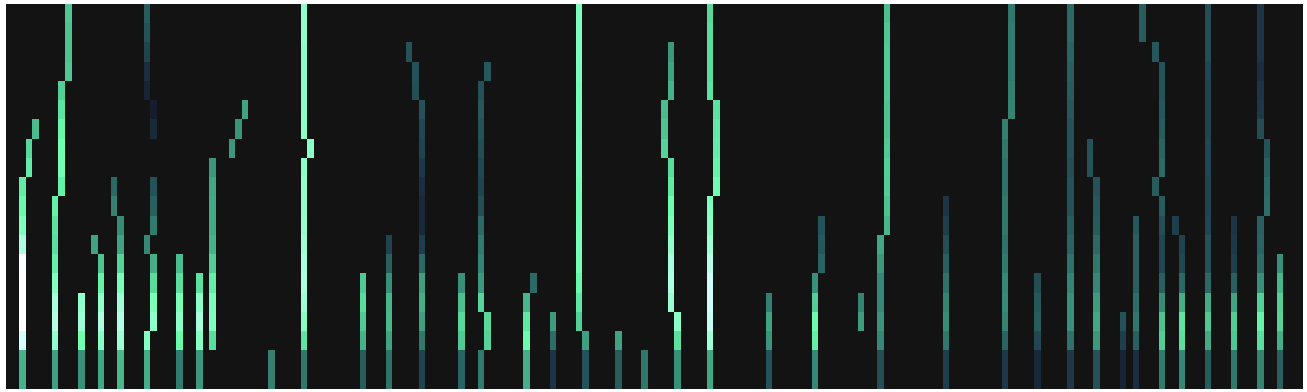
step 4: post-processing

1) localize contiguous parts

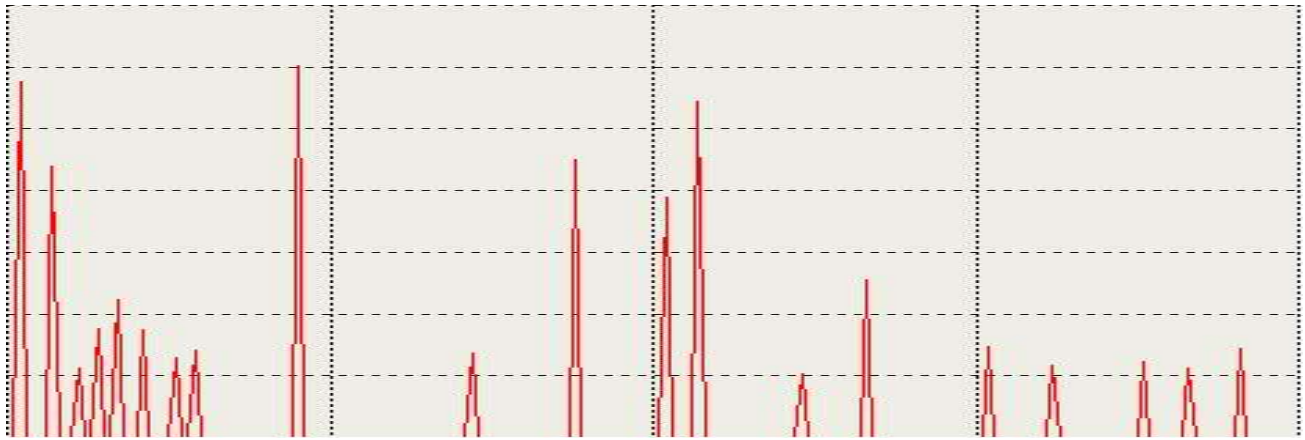
2) sum their values

3) throw away positions
   with too low values

4) refine the positions
   using the spectrogram



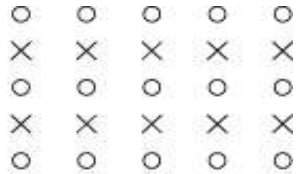
time



Structural Information Theory

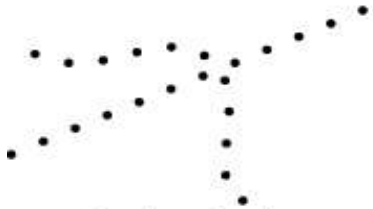
- formal calculus for Gestalt laws

Proximity

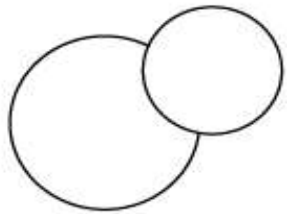


Similarity

- focus on visual patterns



Good continuation



Closure

- experimented with Genetic Programming

- problem:

  need for much higher description, musical objects,

  thus source seperation, classification, ...

Framework for Audio Analysis

- functionality interesting for audio and music research
- integrating research could be fruitful
  - finding musical structure
  - audio signal separation
  - sound classification
  - ...

Python

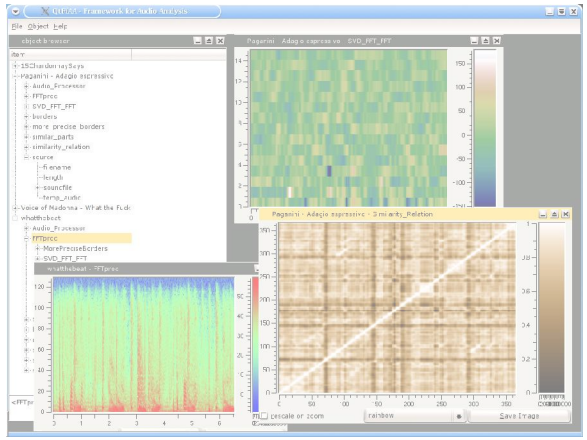
- scripting language, **interpreted**
- **object-oriented**
- **flexible, extensible,** easy to **embed**
- **modular**
- free software (BSD style license)

FfAA modes

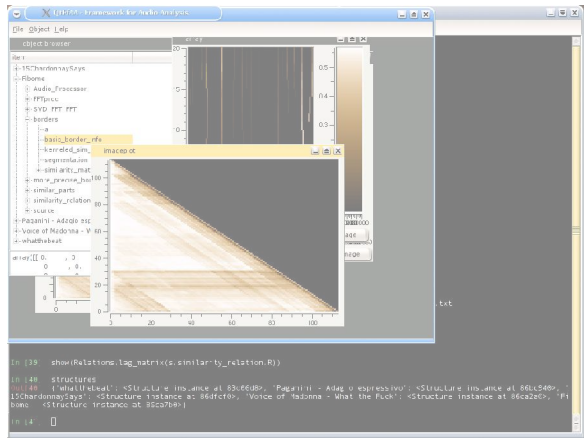
- **Scientific analysis environment**
  - stand-alone application: QtFfAA
  - GUI + command line, object viewer, visualisation
- **Embeddable** in free audio software
  - for audio editors and recorders
  - for music players, DJ tools

FfAA right now

- versatile interface
  - MDI GUI (PyQt)
  - commandline (IPython)



- load and analyse sound files



- database
- visualisation
- easily extensible

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