

# Adaptive Digital Audio Effects

Iman & Minwei

# Outline

## Introduction

For (loudness, tempo, pitch, timbre)

- Feature Extraction
- Feature mapping and control parameters
- Examples of Adaptive DAFX
- Demo

## Conclusion

# Introduction

## Adaptive Digital Audio Effects

The sound to be transformed is also used as the source of the modification control parameters.

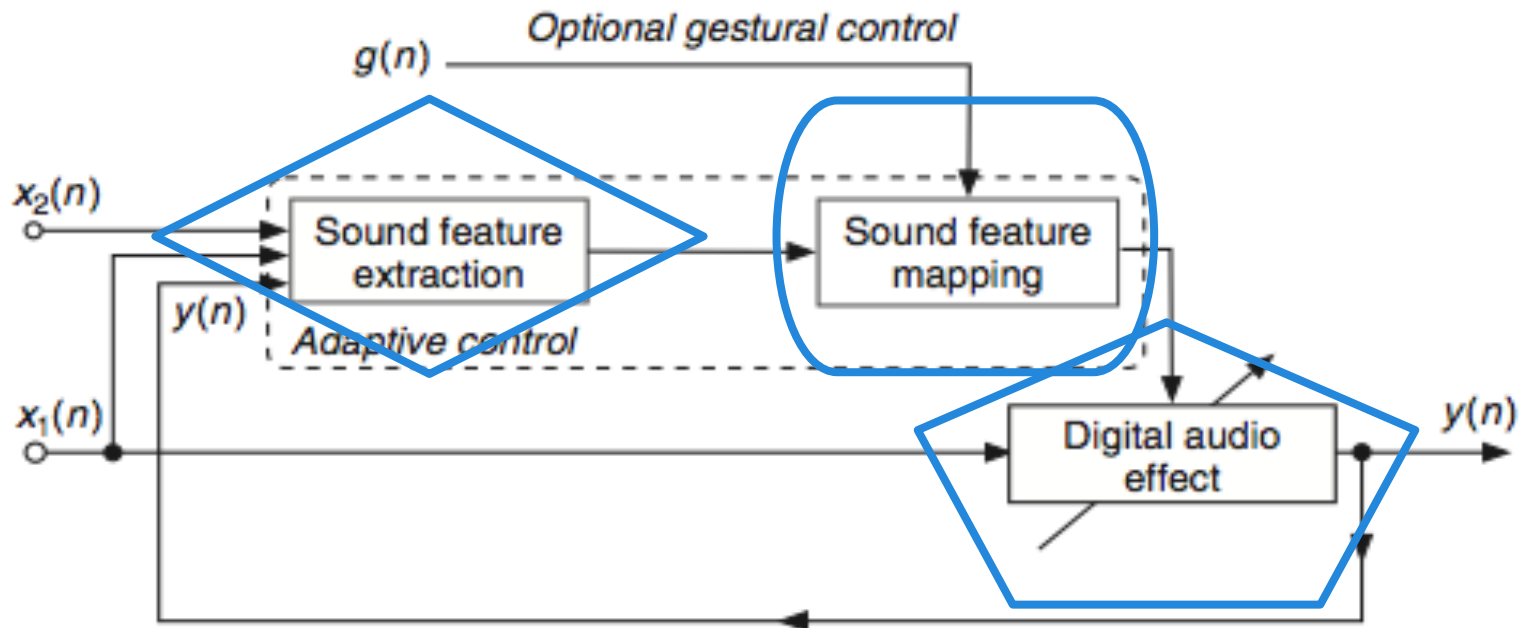
### Motivation:

higher level control / propose new production

strengthen the relationship between Effects, control, perception

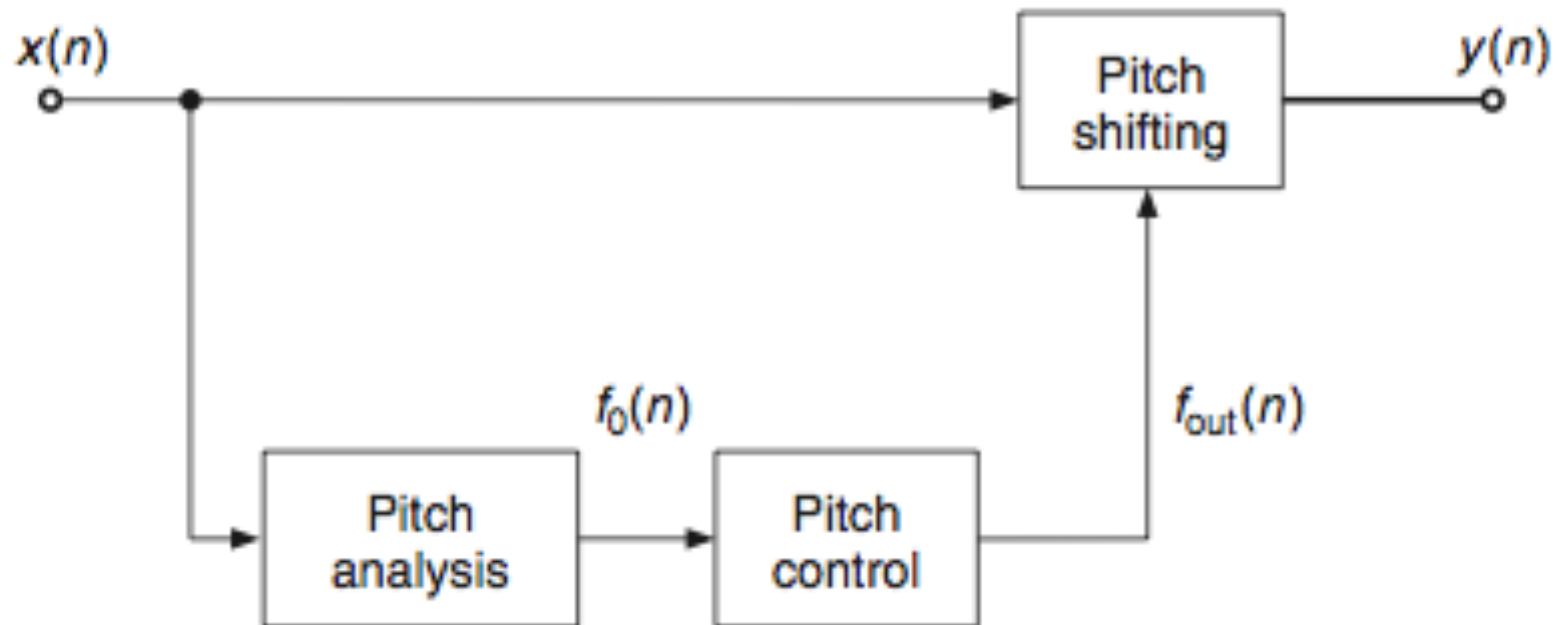
# Introduction

## General Flowchart of Adaptive DAFX



# Introduction

A classical Example: Auto - Tune



# Introduction

## Classifications:

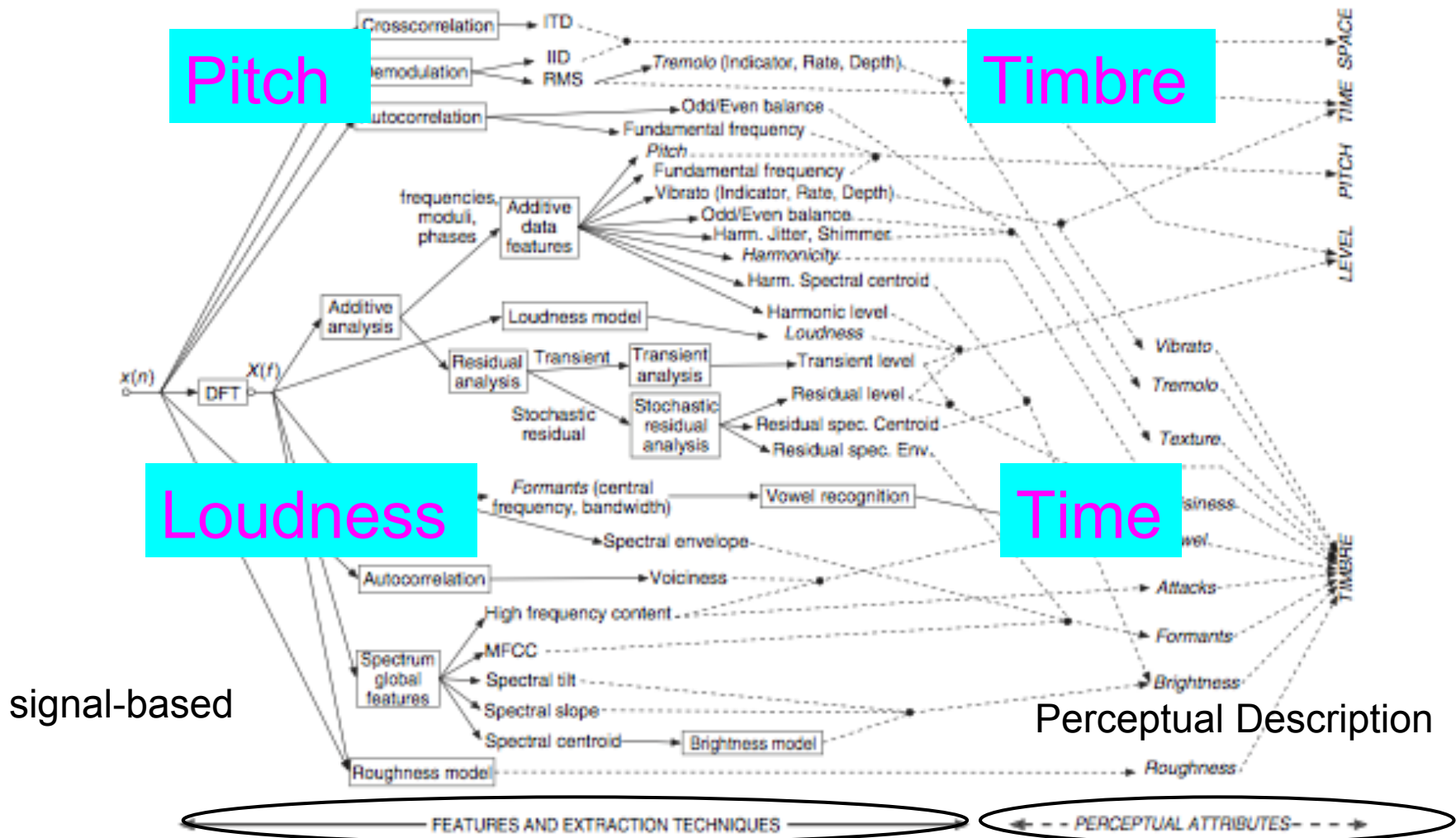
Auto-Adaptive: compressor, autotune

External-Adaptive: cross-ducking

Feedback Adaptive:

Cross-Adaptive: cross synthesis, automatic mixing

# Feature Extraction - Classification



# Pitch - Feature Extraction

Task Definition:

to estimate a **fundamental frequency**  $F_0$

- frequency domain

- FFT-based approach

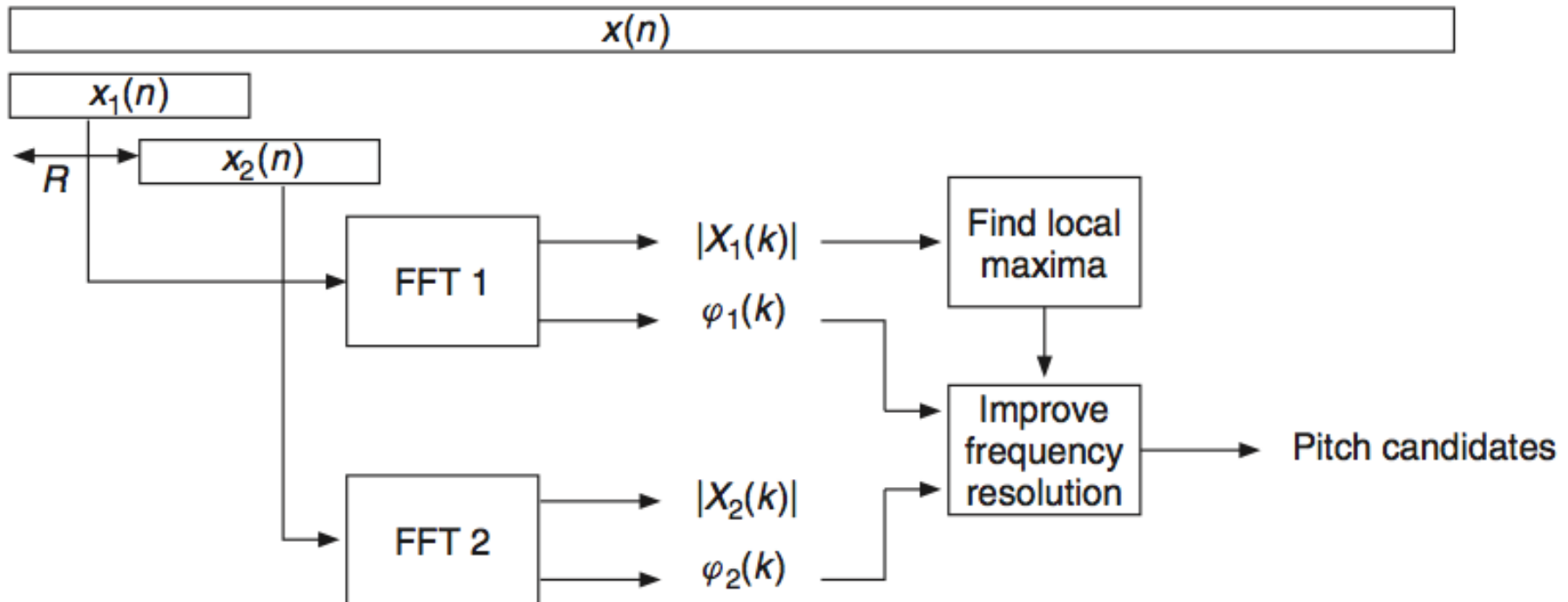
- time domain

- Auto correlation
- Yin Algorithm
- Long-term Prediction



# Pitch - Feature Extraction

## FFT-Based Approach

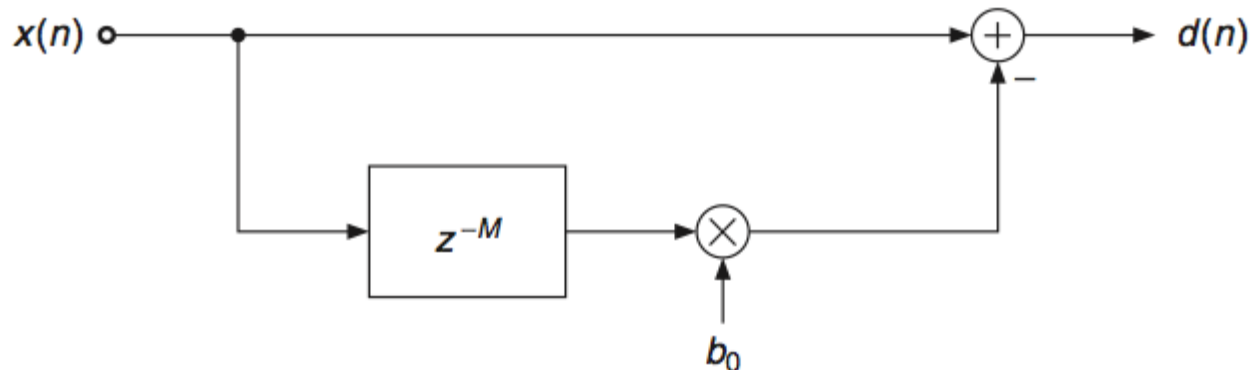


# Pitch - Feature Extraction

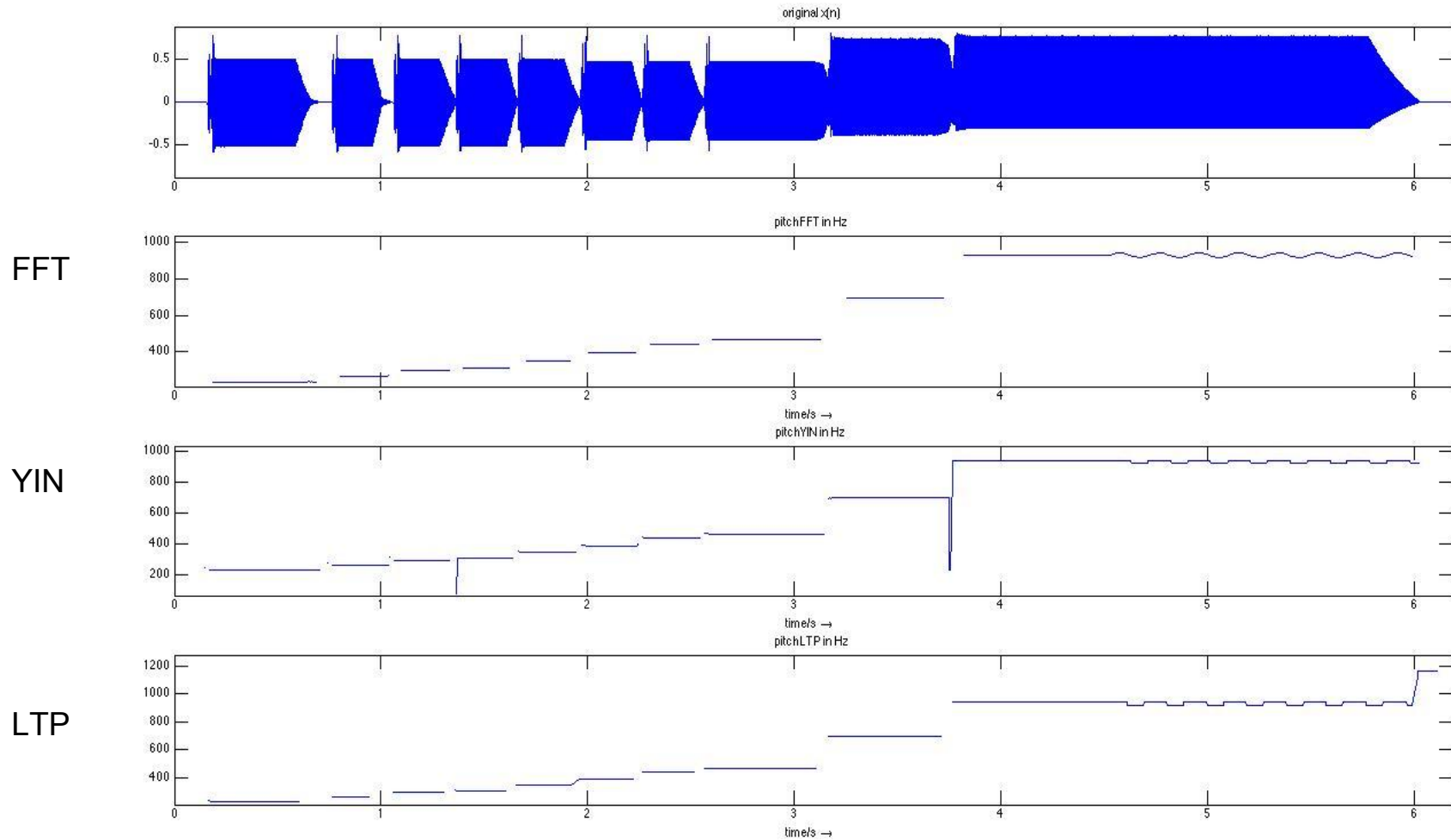
Yin Algorithm: calculate the sum of differences of a time frame

$$d'_t(l) = \begin{cases} 1, & l = 0 \\ \frac{d_t(l)}{\frac{1}{l} \sum_{n=1}^l d_t(n)}, & \text{else.} \end{cases}$$

Long-Term Prediction: Apply FIR to a pitch Delay Line



# Pitch - Results Comparison



# Timbre - Feature Extraction

The most difficult perceptual attributes. Sound features related to timbre:

Brightness - Spectral Centroid

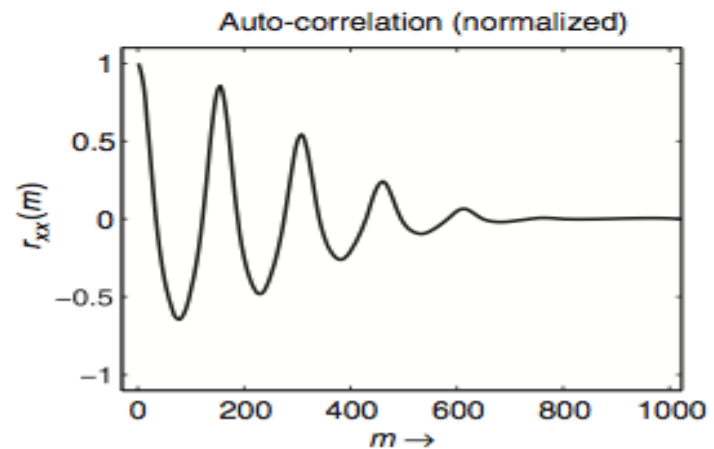
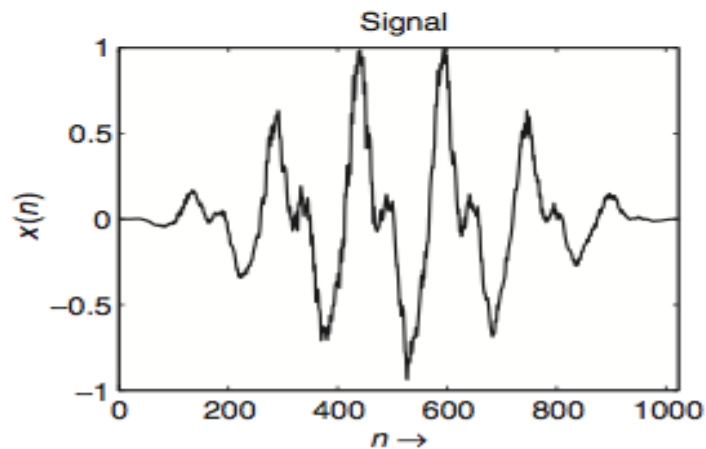
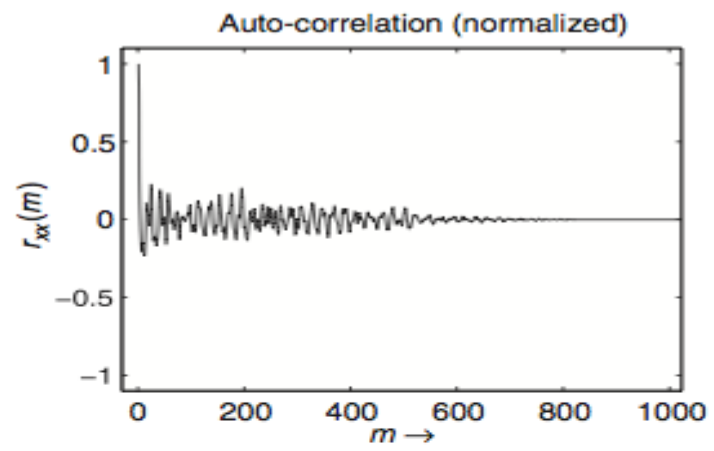
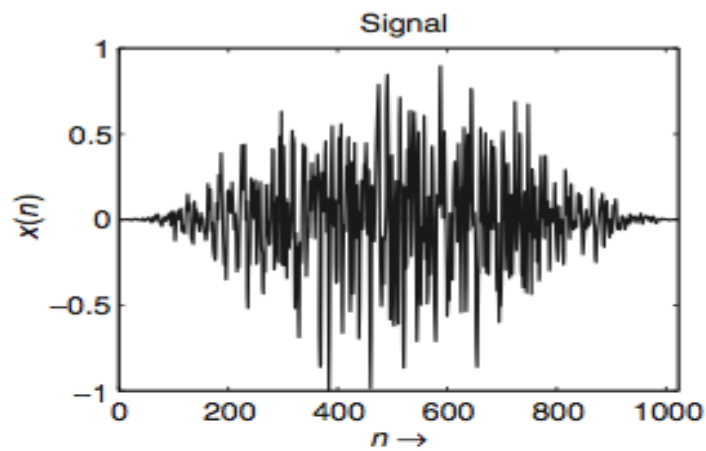
Quality and noisiness - SNR

Textures - Harmonic Partial

Formants - MFCC, vowels for the voice  
etc...

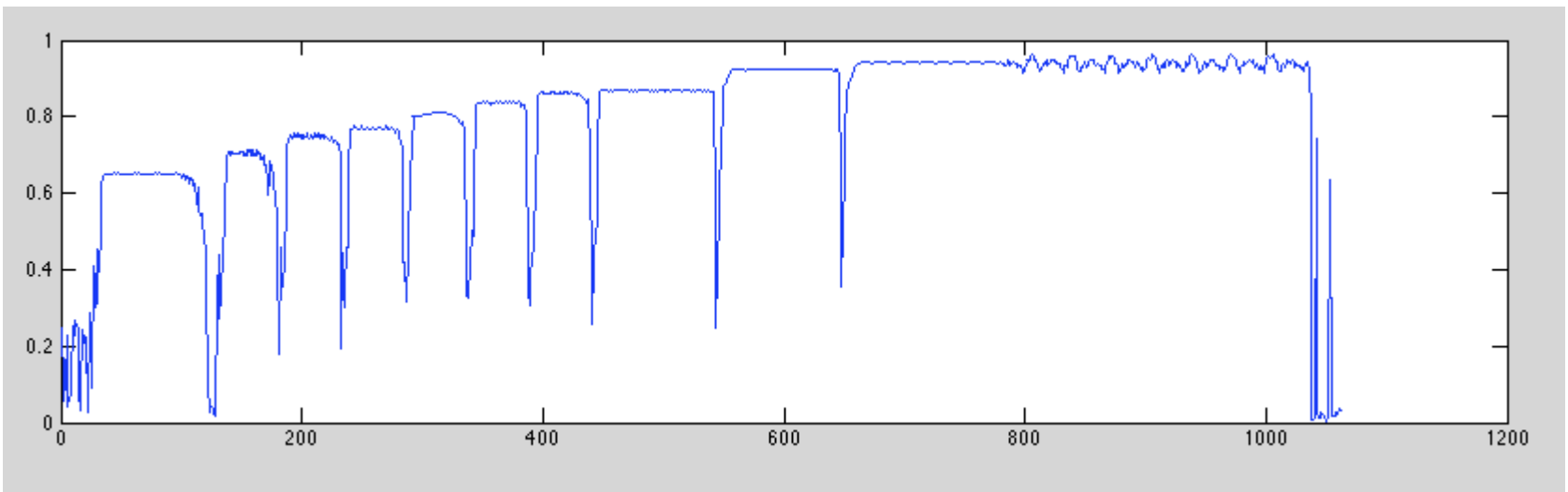
# Timbre - Feature Extraction

Auto - Correlation: voiced/unvoiced sound



# Timbre - Feature Extraction

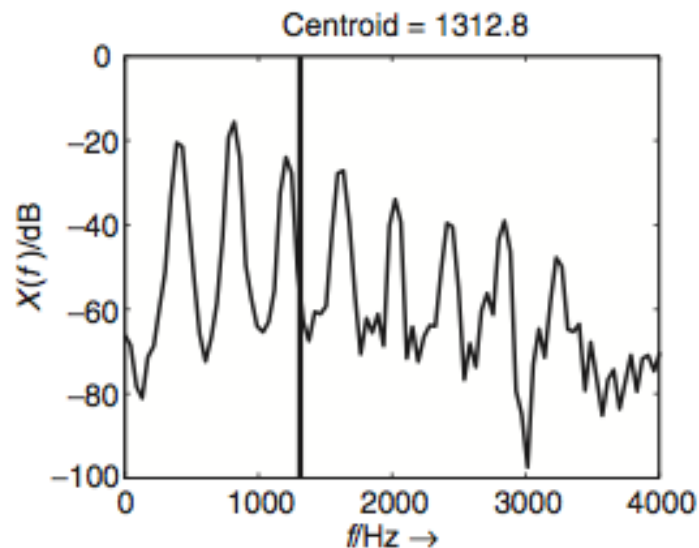
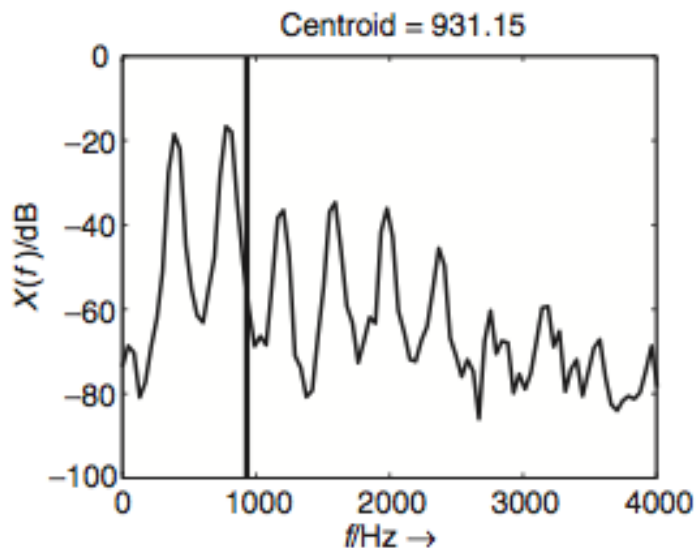
Compute auto-correlation from the power spectrum, do IFFT of the magnitude  $|X(k)|$  (square root of the power spectrum)



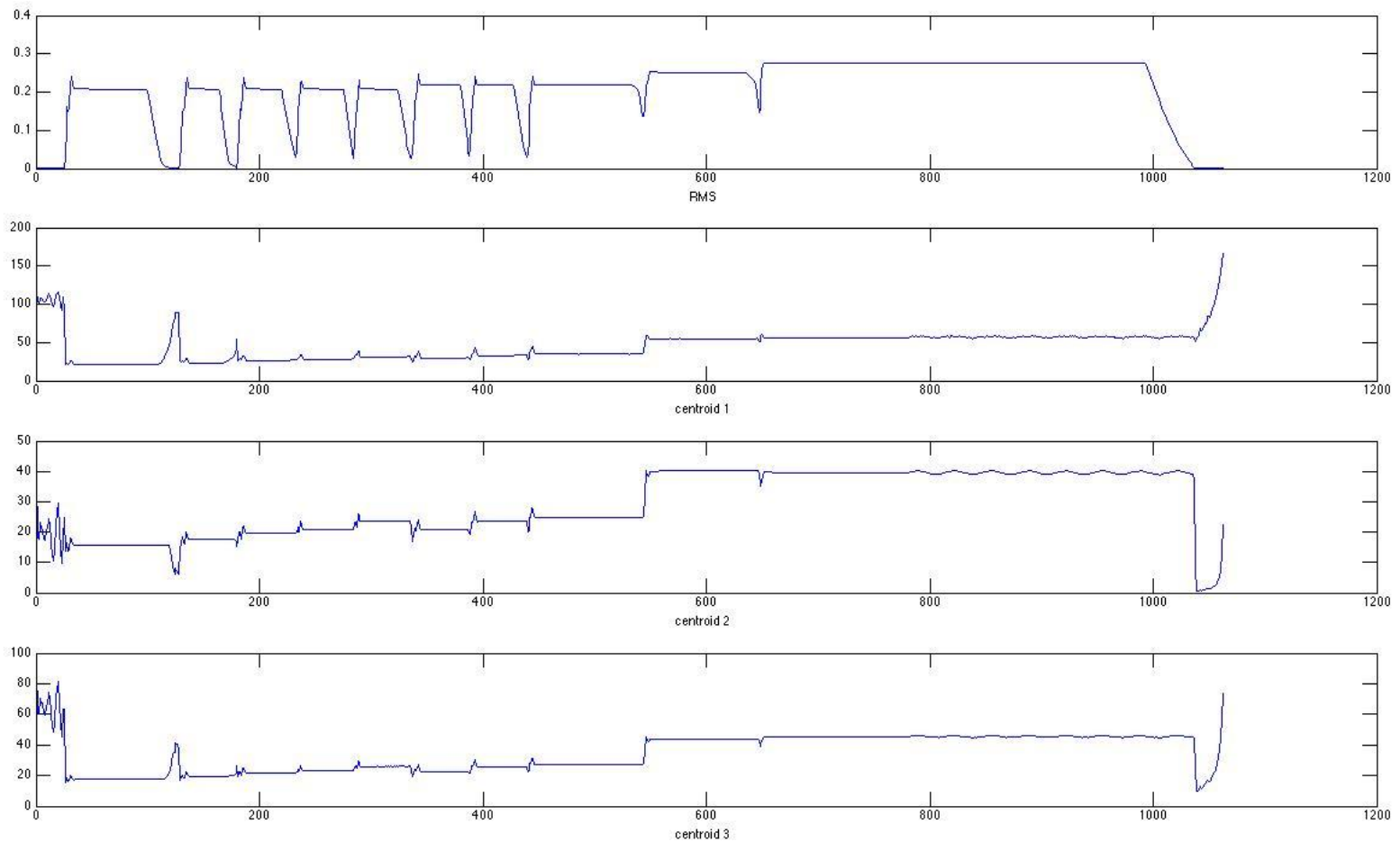
# Timbre - Feature Extraction

Spectral Centroid: richness of harmonics:

- A sound with a fixed pitch with **strong harmonics** will have **higher center of gravity**



# Timbre - Feature Extraction





# Adaptive Effects Examples

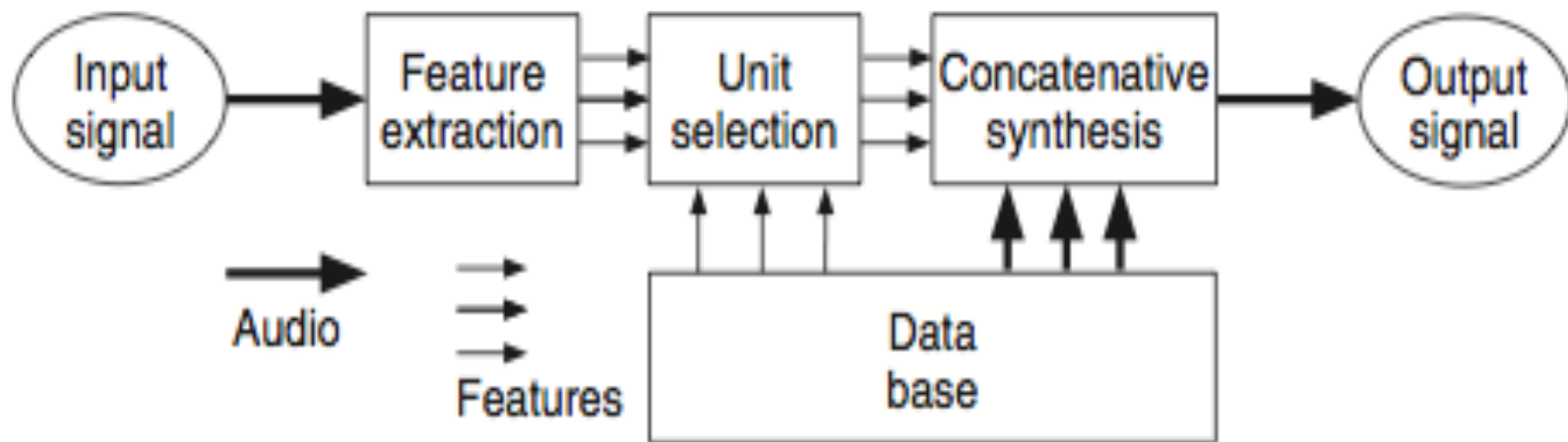
Adaptive Pitch-shifting:

- 1.adaptive detuning: obtained by transfer a signal to its pitch-shifted version with a lower than **a quarter-tone ratio**
- 2.harmonizer: a vocal chorus can be harmonized by **adding a pitch-shifted version sound** to create a chord (I have a demo)

Adaptive Effects on Timbre:

voice morphing, voice conversion, automatic vibrato, spectral tremolo, adaptive spectral warping (no demo today, google yourself)

# Combination Features adaptive- Concatenative Synthesis



# Loudness related features

- Amplitude Envelope
- Sound Energy
- Loudness
- Tremolo Description

# Amplitude Envelope

- No unique definition
- Slow variations ( $< 10$  Hz)
- 'Shape' and 'Matter'
- MATLAB: Example using RMS Algorithm

# Sound Energy

Squared Amplitude

# Loudness

- Energy is summed over a critical band, after accounting for frequency masking
- Improved by accounting for integration time and masking
- Different loudness curves as control curves for adaptive effect control

# Tremolo Descriptions

Sinusoidal model of amplitude envelope

- Rate or frequency
- Amplitude depth
- Phase

Then, features mapped to time stretching of vibrato for e.g.

# Time features

- Beat Detection and Tracking

## Tempo/BPM to control effect parameters

- Delay-time settings
- Speed of parameter modulation
- Gates for reverb etc.

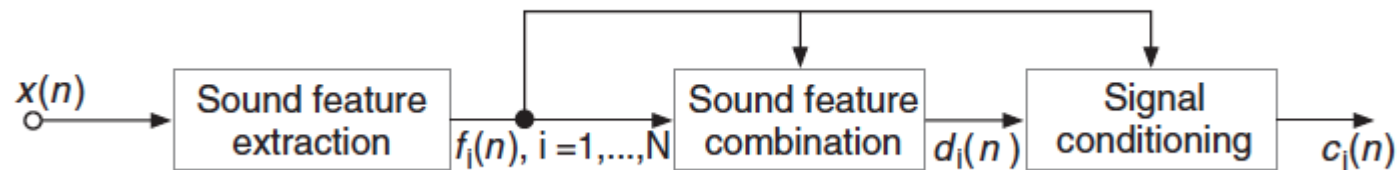


# Harmonic/Percussion separation

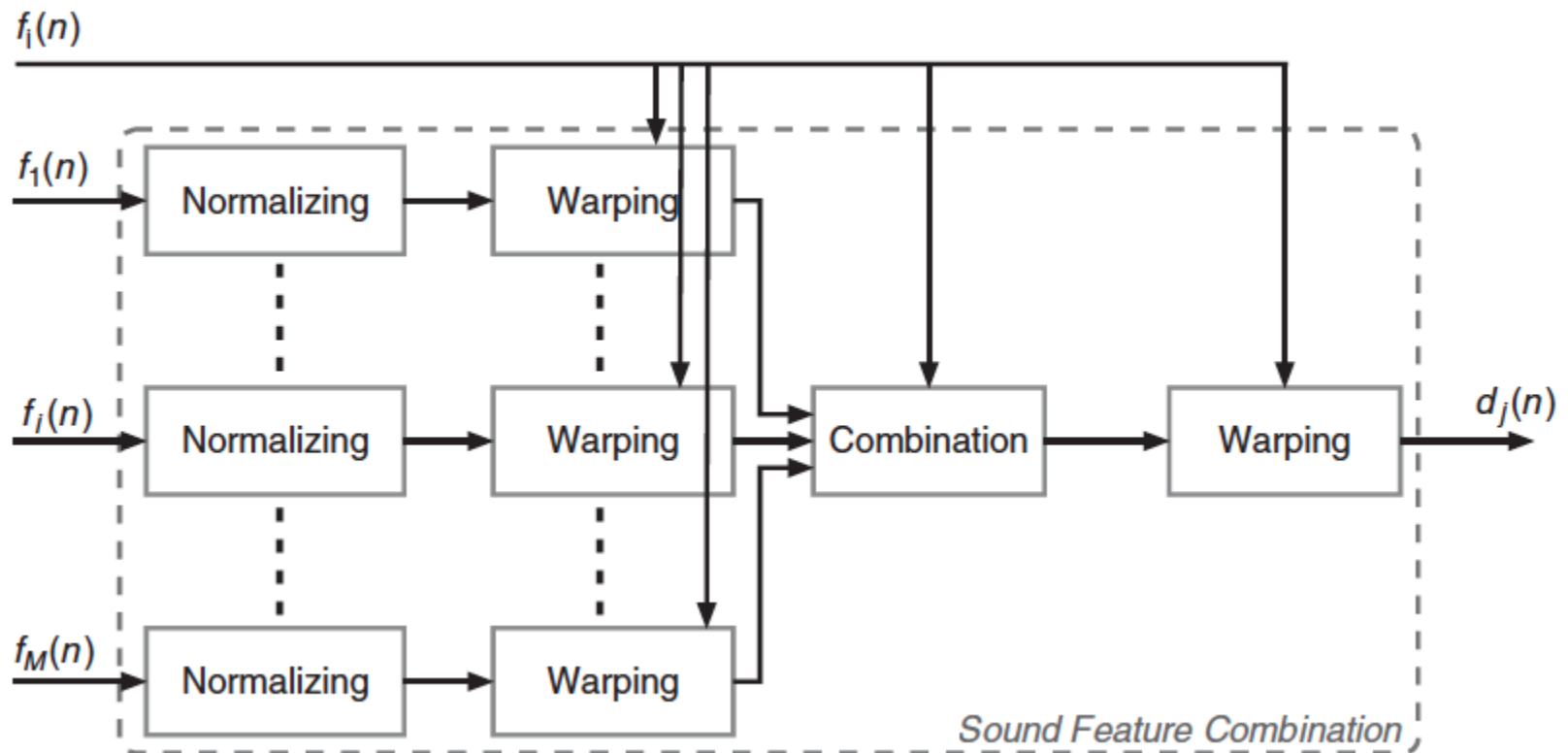
- Processing on the spectrogram, making use of median filtering across each frame in frequency direction and across each frequency bin in the time direction
- As a first approximation, broadband noise signals such as drums can be regarded as stable vertical ridges in a spectrogram
- Narrow band signals, such as the harmonics from a pitched instrument, will result in an increase in energy within a bin over and above that due to the drum instrument, resulting in outliers in the spectrogram frame

# Mapping sound features to control parameters

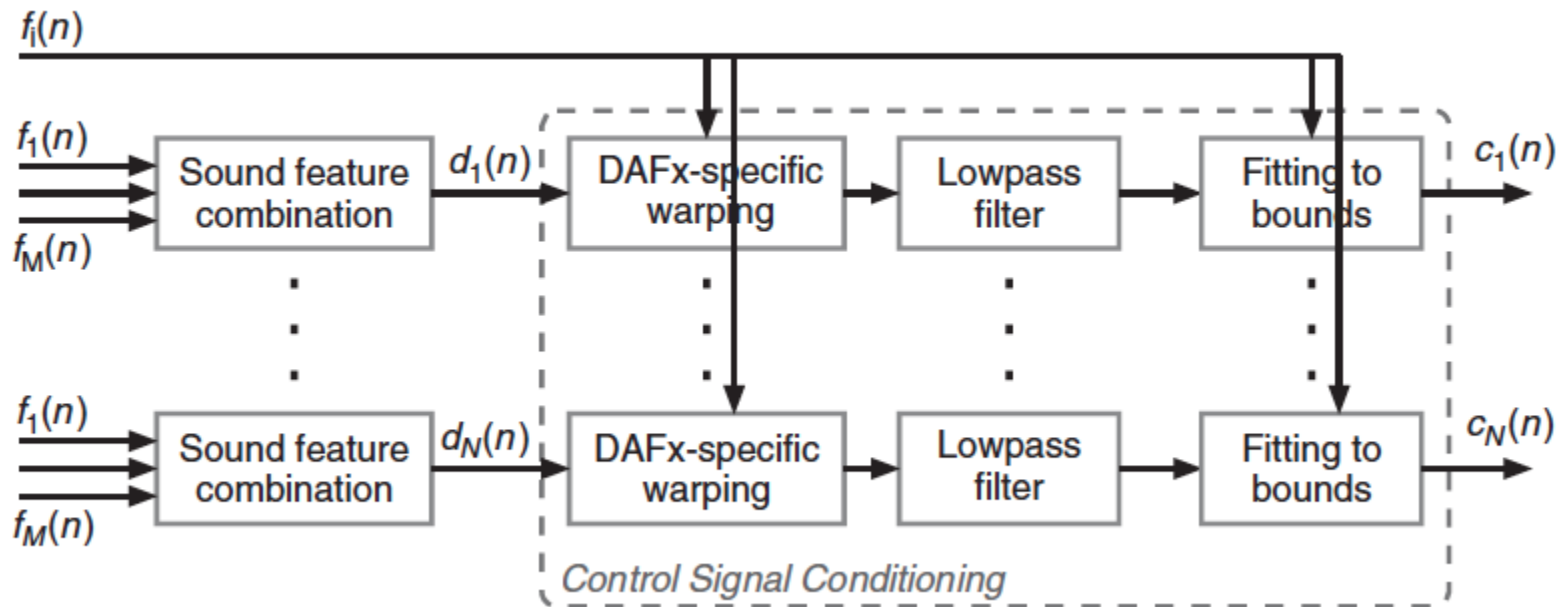
- The Mapping Structure
  - Sound-feature combination
  - Control-signal conditioning



# Sound-Feature Combination



# Control-Signal Conditioning



# More examples of ADAFX

- Adaptive Sound-level change
- Adaptive Tremolo
- Adaptive Time-warping
- Adaptive Panning

# Even more...

- Multi-dimensional adaptive effects
  - Adaptive robotization
  - Adaptive granular delay

Q n A

THANK YOU!