Lecture

Information Retrieval for Music and Motion

Meinard Müller

Summer Term 2008

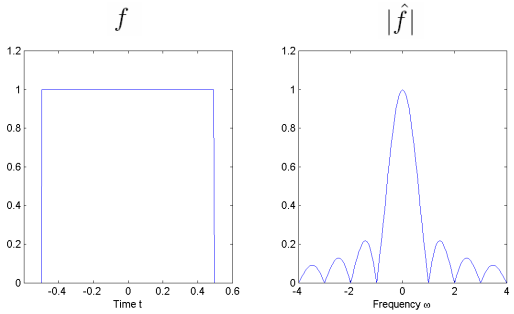
Audio Features

UNIVERSITÄT DES SAARLANDES

MPI max planck institut informatik

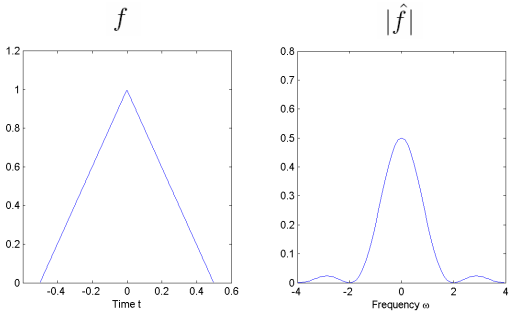
Window Functions

Box window



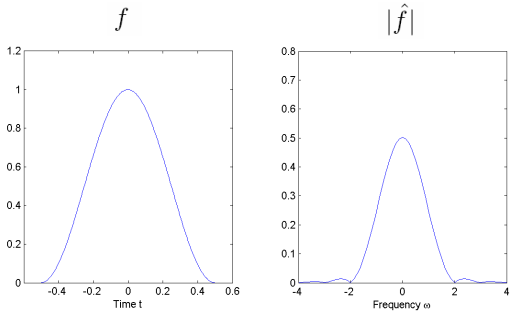
Window Functions

Triangle window



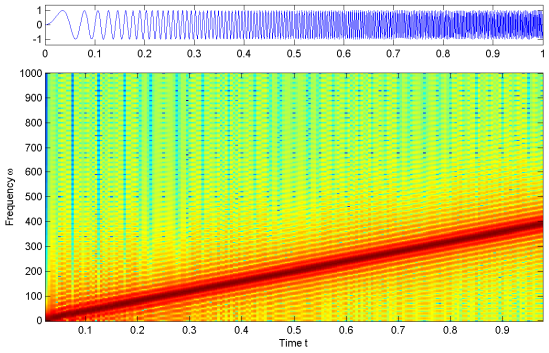
Window Functions

Hanning window



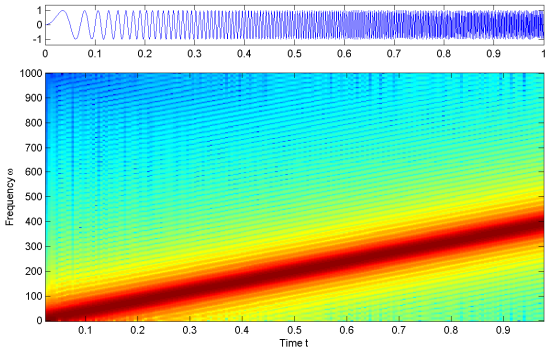
Windowed Fourier Transform (WFT)

Chirp signal and WFT with box window of length 0.05



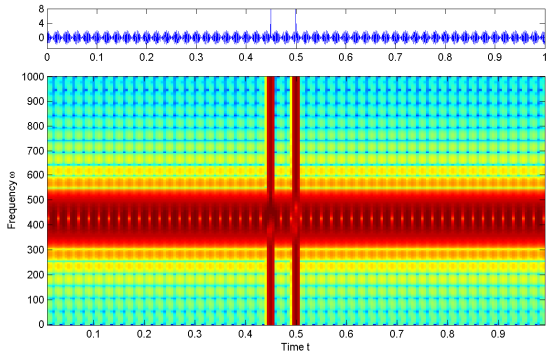
Windowed Fourier Transform (WFT)

Chirp signal and WFT with hanning window of length 0.05



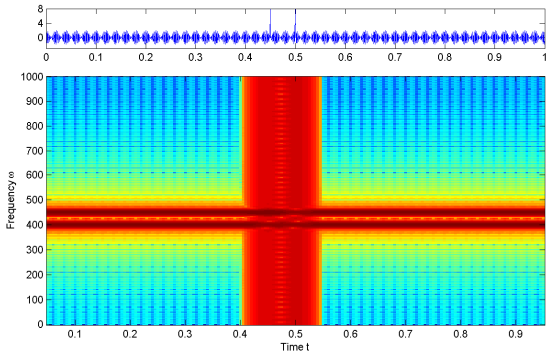
Windowed Fourier Transform (WFT)

Signal and WFT with hanning window of length 0.02



Windowed Fourier Transform (WFT)

Signal and WFT with hanning window of length 0.1



Heisenberg Uncertainty Principle

Window function $g \in L^2(\mathbb{R})$ with $\|g\| = 1$

Center

$$t_0 = t_0(g) := \int_{-\infty}^{\infty} t|g(t)|^2 dt$$

$$\omega_0 = \omega_0(g) := \int_{-\infty}^{\infty} \omega|\hat{g}(\omega)|^2 d\omega$$

Width

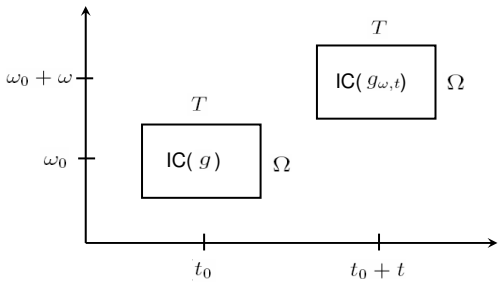
$$T(g) := \left(\int_{-\infty}^{\infty} (t-t_0)^2|g(t)|^2 dt\right)^{\frac{1}{2}}$$

$$\Omega(g) := \left(\int_{-\infty}^{\infty} (\omega-\omega_0)^2|\hat{g}(\omega)|^2 d\omega\right)^{\frac{1}{2}}$$

$$T(g) \cdot \Omega(g) \geq \frac{1}{4\pi}$$

Information Cells

$g_{\omega,t}(u) := e^{2\pi i\omega u} g(u-t)$ "musical note"

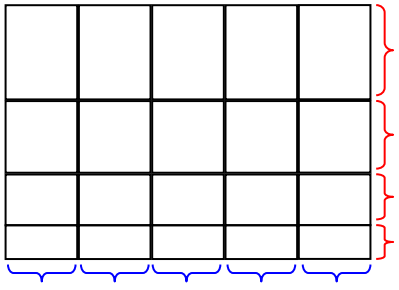


Pitch Features

Note	MIDI pitch	Center frequency	Left boundary	Right boundary	Width
A3	57	220.0	213.7	226.4	12.7
A#3	58	233.1	226.4	239.9	13.5
B3	59	246.9	239.9	254.2	14.3
C4	60	261.6	254.2	269.3	15.1
C#4	61	277.2	269.3	285.3	16.0
D4	62	293.7	285.3	302.3	17.0
D#4	63	311.1	302.3	320.2	18.0
E4	64	329.6	320.2	339.3	19.0
F4	65	349.2	339.3	359.5	20.2
F#4	66	370.0	359.5	380.8	21.4
G4	67	392.0	380.8	403.5	22.6
G#4	68	415.3	403.5	427.5	24.0
A4	69	440.0	427.5	452.9	25.4

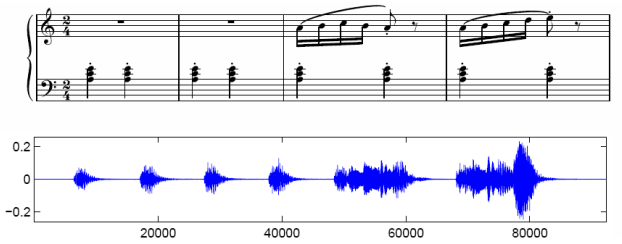
Pitch Features

Time-frequency representation



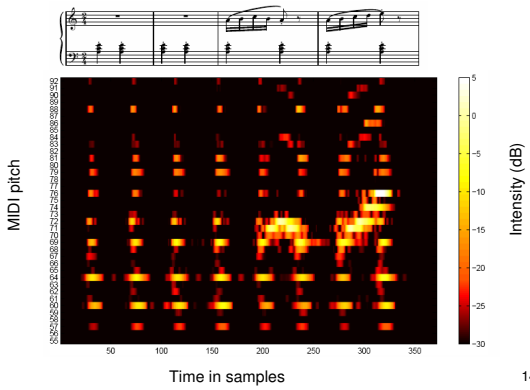
Pitch Features

Op. 100, No. 2 by Friedrich Burgmüller



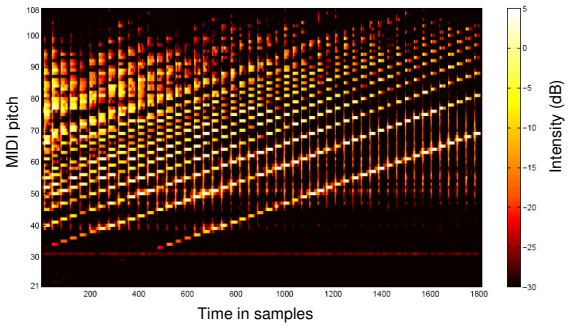
Pitch Features

Time-pitch plot



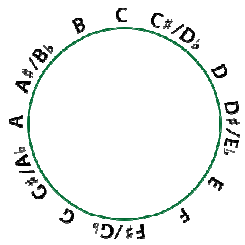
Pitch Features

Time-pitch plot



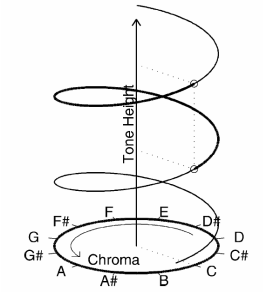
Chroma Features

Chromatic circle



http://en.wikipedia.org/wiki/Pitch_class_space

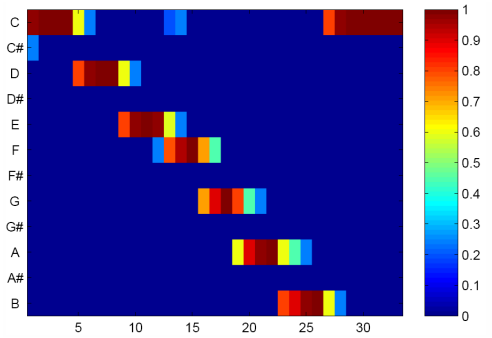
Shepard's helix of pitch perception



Bartsch/Wakefield, IEEE Trans. Multimedia, 2005

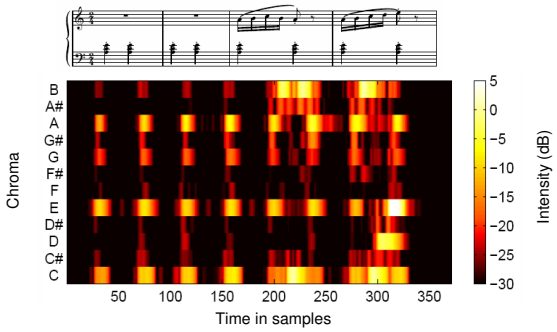
Chroma Features

Example: C-Major Scale



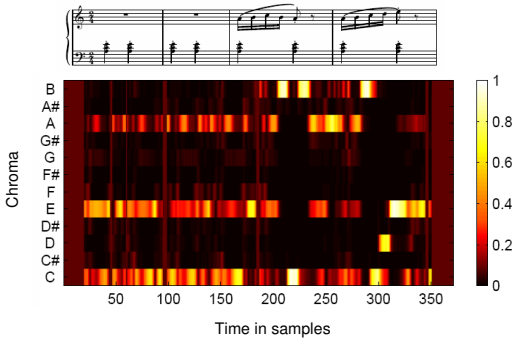
Chroma Features

Example: Burgmüller Op. 100, No. 2



Chroma Features

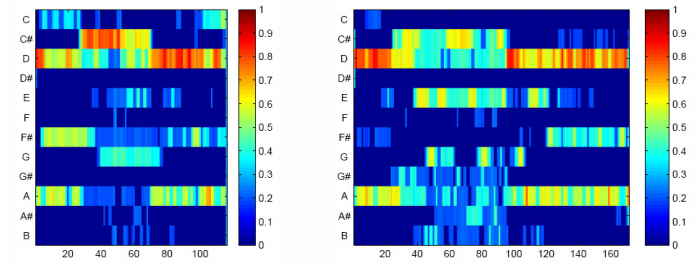
Normalization



Chroma Features

Example: Bach Toccata

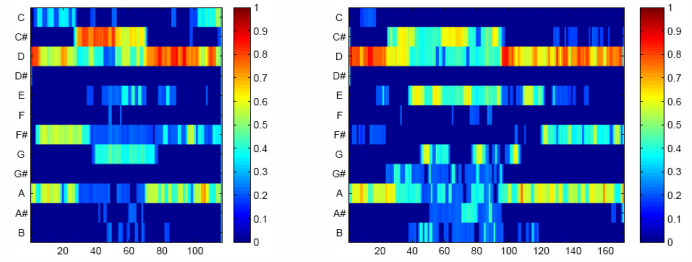
Koopman ▶ ▶ Ruebsam ▶ ▶



Chroma Features

Example: Bach Toccata

Koopman ▶ ▶ Ruebsam ▶ ▶

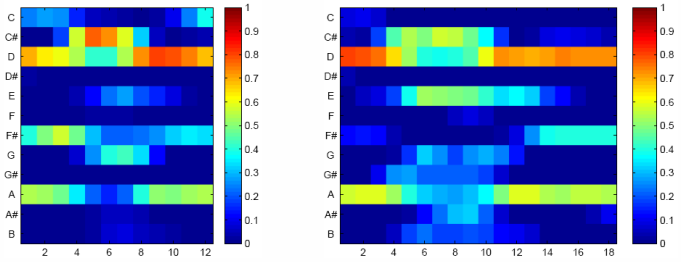


Feature resolution: 10 Hz

Chroma Features

Example: Bach Toccata

Koopman ▶ ▶ Ruebsam ▶ ▶

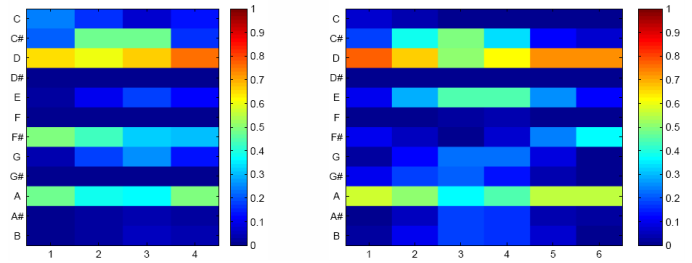


Feature resolution: 1 Hz

Chroma Features

Example: Bach Toccata

Koopman ▶ ▶ Ruebsam ▶ ▶



Feature resolution: 0.33 Hz

Chroma Features

	WAV	Chroma (10 Hz)	CENS (1 Hz)
???	▶	▶	▶
???	▶	▶	▶
???	▶	▶	▶

Chroma Features

	WAV	Chroma (10 Hz)	CENS (1 Hz)
Beethoven's Fifth (Bernstein)	▶	▶	▶
???	▶	▶	▶
???	▶	▶	▶

Chroma Features

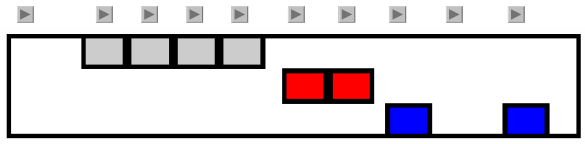
	WAV	Chroma (10 Hz)	CENS (1 Hz)
Beethoven's Fifth (Bernstein)	▶	▶	▶
Beethoven's Fifth (Piano/Sherbakov)	▶	▶	▶
???	▶	▶	▶

Chroma Features

	WAV	Chroma (10 Hz)	CENS (1 Hz)
Beethoven's Fifth (Bernstein)	▶	▶	▶
Beethoven's Fifth (Piano/Sherbakov)	▶	▶	▶
Brahms Hungarian Dance No. 5	▶	▶	▶

Chroma Features

Example: Zager & Evans "In The Year 2525"

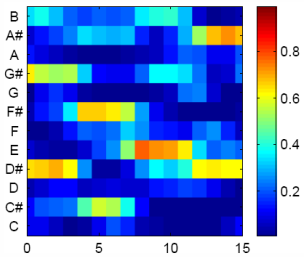


How to deal with transpositions?

Chroma Features

Example: Zager & Evans "In The Year 2525"

▶ ▶

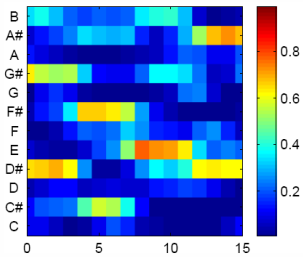


Original: $(v^1, \ldots, v^N)$

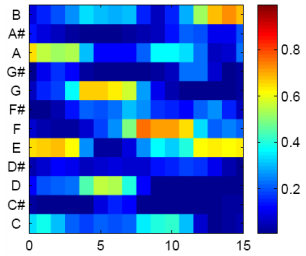
Chroma Features

Example: Zager & Evans "In The Year 2525"

▶ ▶ ▶ ▶



Original: $(v^1, \ldots, v^N)$



Shifted: $(\sigma(v^1), \ldots, \sigma(v^N))$