TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical and Computer Engineering , Communications Laboratory, Deutsche Telekom Chair of Communication Networks

Compressed Compute-and-Forward with correlated audio signals

Dresden, 14.07.2016

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

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Task

- develop software to correlate stereo audio streams
- develop models for characteristic values to describe correlation
- record audio signals

Underlying theory (crosscorrelation)

time domain

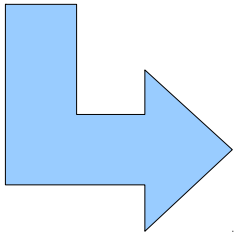
$$\psi_{xy}^{E}(\tau) = \int_{-\infty}^{\infty} x(t) \cdot y(t+\tau)\,\mathrm{d}t$$

[ISV, S. 48 f]

frequency domain

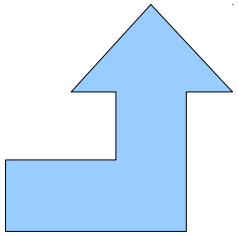
$$\underline{\Psi}(\omega) = \underline{X}^{*}(\omega) \cdot \underline{Y}(\omega)$$

[ISV, S. 180]



$$\underline{\Psi}(\omega) = \int_{-\infty}^{\infty} x(-t) * y(t) \cdot e^{-j\omega t}\,dt$$

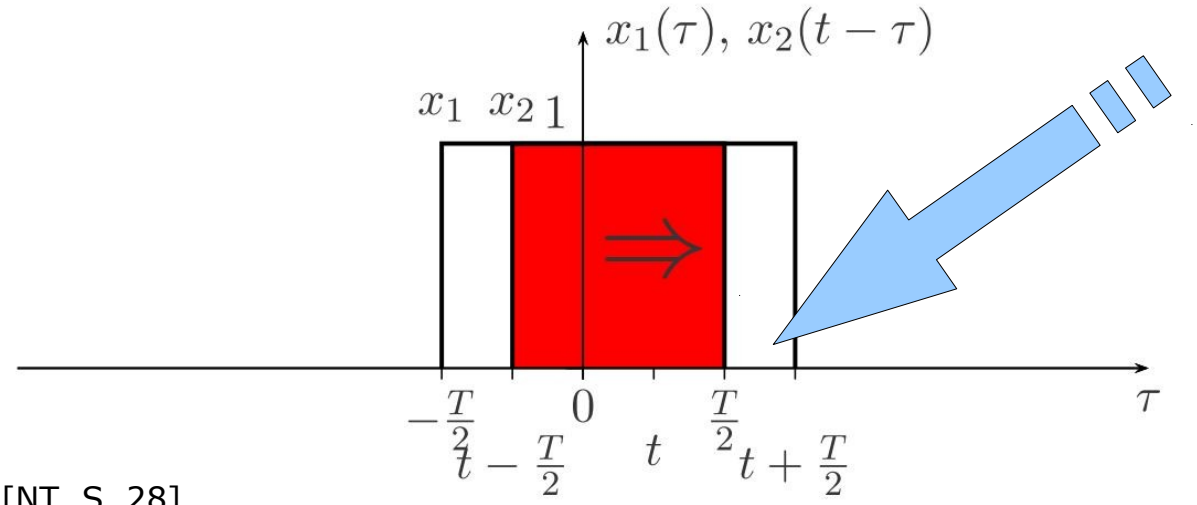
[ISV, S. 180]



convolution theorem

[ISV] Rüdiger Hoffmann, Matthias Wolff: Intelligente Signalverarbeitung 1. Springer Verlag Berlin Heidelberg 2014

Underlying theory



[NT, S. 28]

[NT]Prof. Dr.-Ing. Dr. h.c. Gerhard P. Fettweis: Einführung in die Nachrichtentechnik. Technische Universität Dresden, Fakultät Elektrotechnik, Vodafone Stiftungslehrstuhl Mobile Nachrichtensysteme, D-01062 Dresden Sommersemester 2015

Designed Characteristical Values

- Aim: check what kinds of signals are suitable for compressed-sensing
  → classify signals
- Categories: physical information and shape of cross-correlation
- express characteristics in numbers
  -simplify characteristics
  -developed parameters have to stay valid

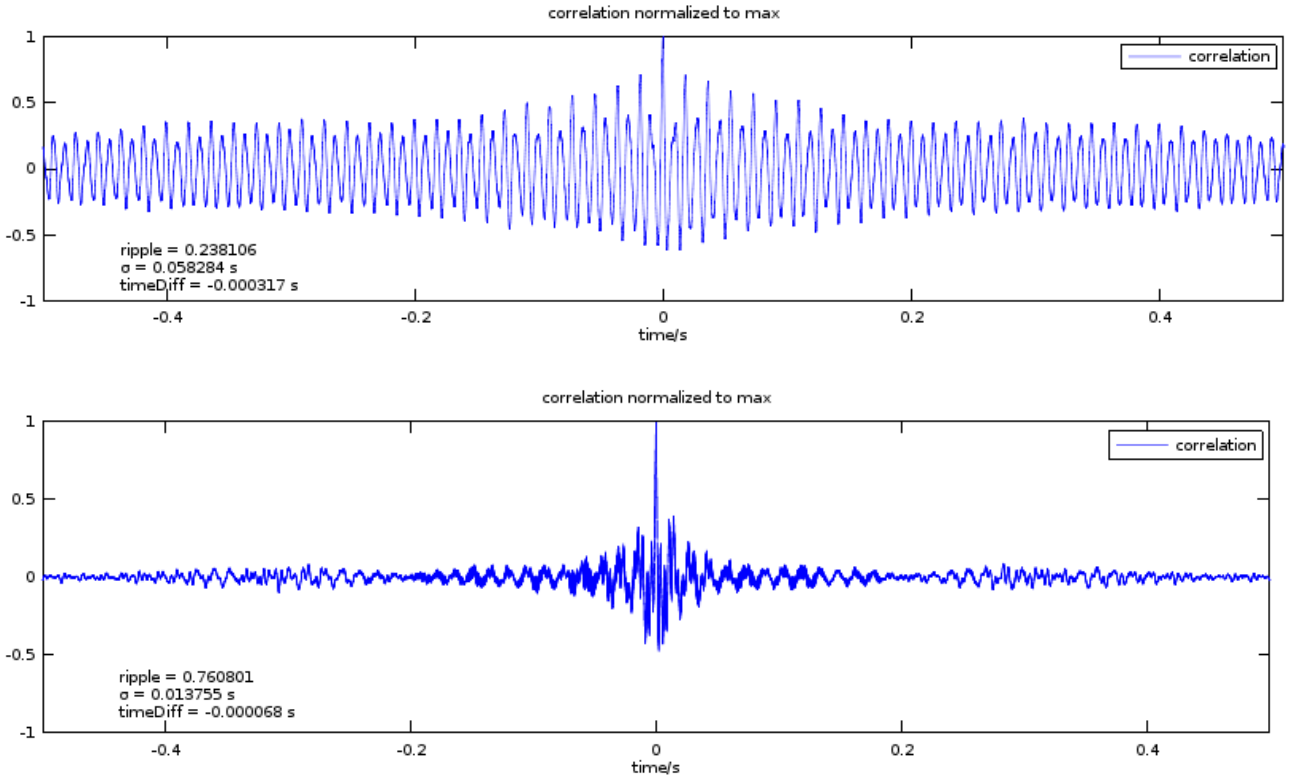
Designed Characteristical Values – ripple

- Scale for energy distribution of the signal

$$ripple = \frac{\sum_{\text{der obersten 5 Perzentile}} x_i^2}{\sum_{i=1}^{N} x_i^2}$$

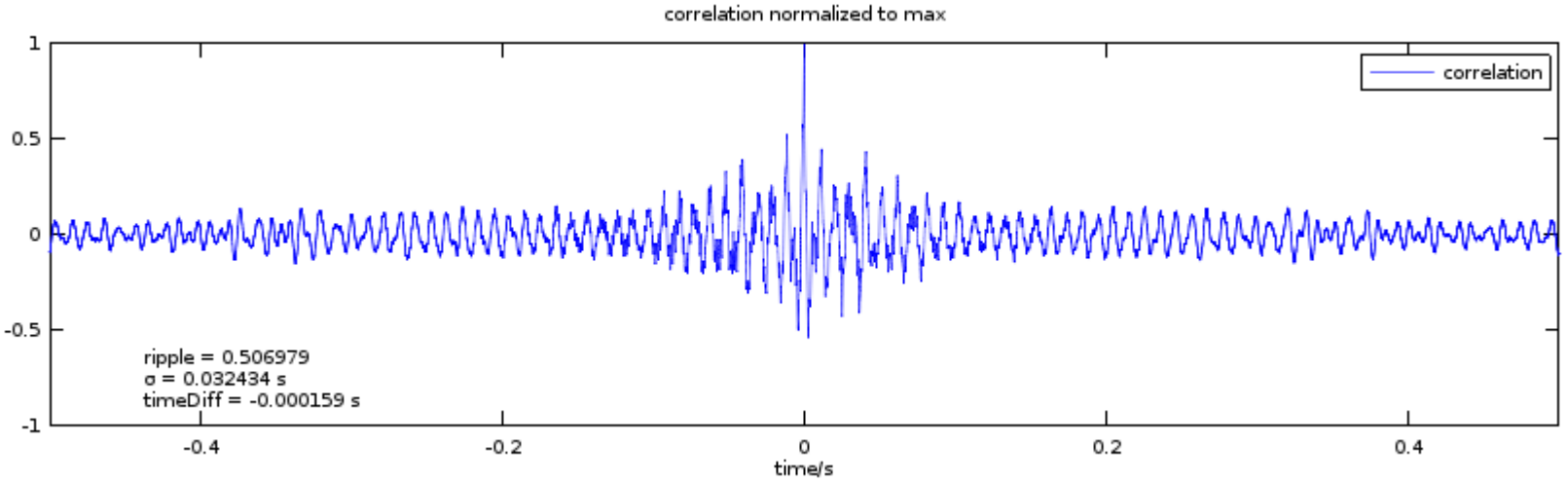
- $0 \leq ripple \leq 1$

Designed Characteristical Values – ripple



Designed Characteristical Values – sigma

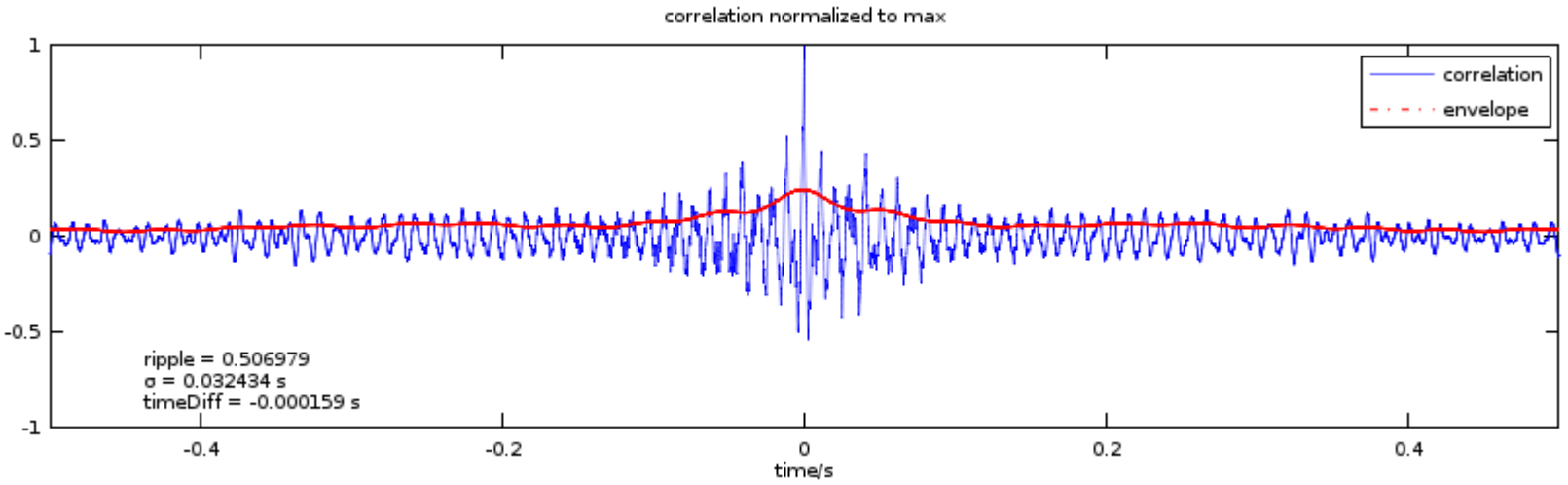
- Typical shape of a cross-correlation:



- Find a scale for width of the peak

Designed Characteristical Values – sigma

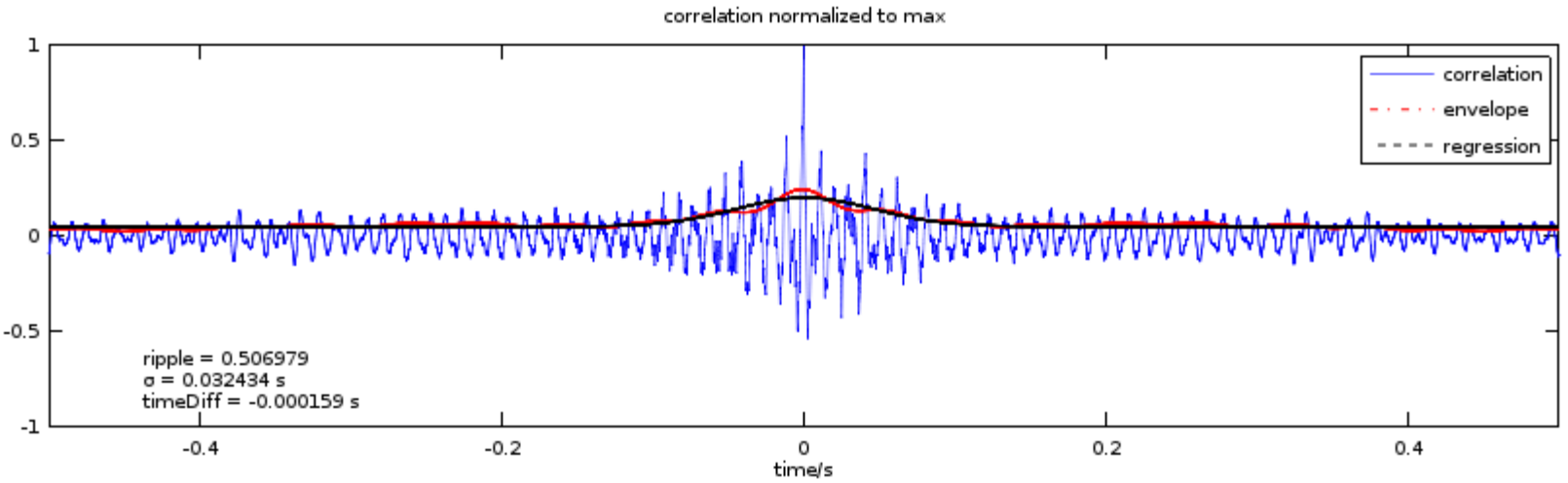
- Amplitude-demodulation to receive an "envelope":



Designed Characteristical Values – sigma

- Fit a bell-shaped curve to envelope:

$$y = a \cdot e^{-\frac{(x-\mu)^2}{2\sigma^2}} + b$$



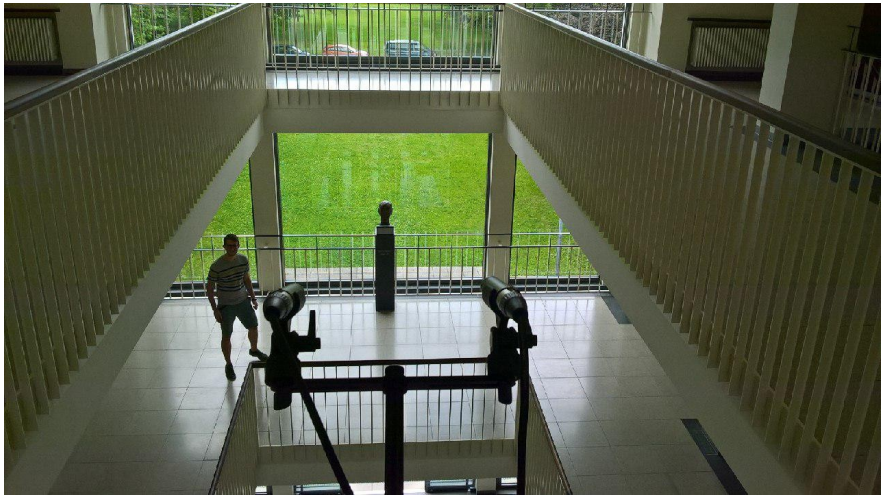
- Take sigma as value

Octave script

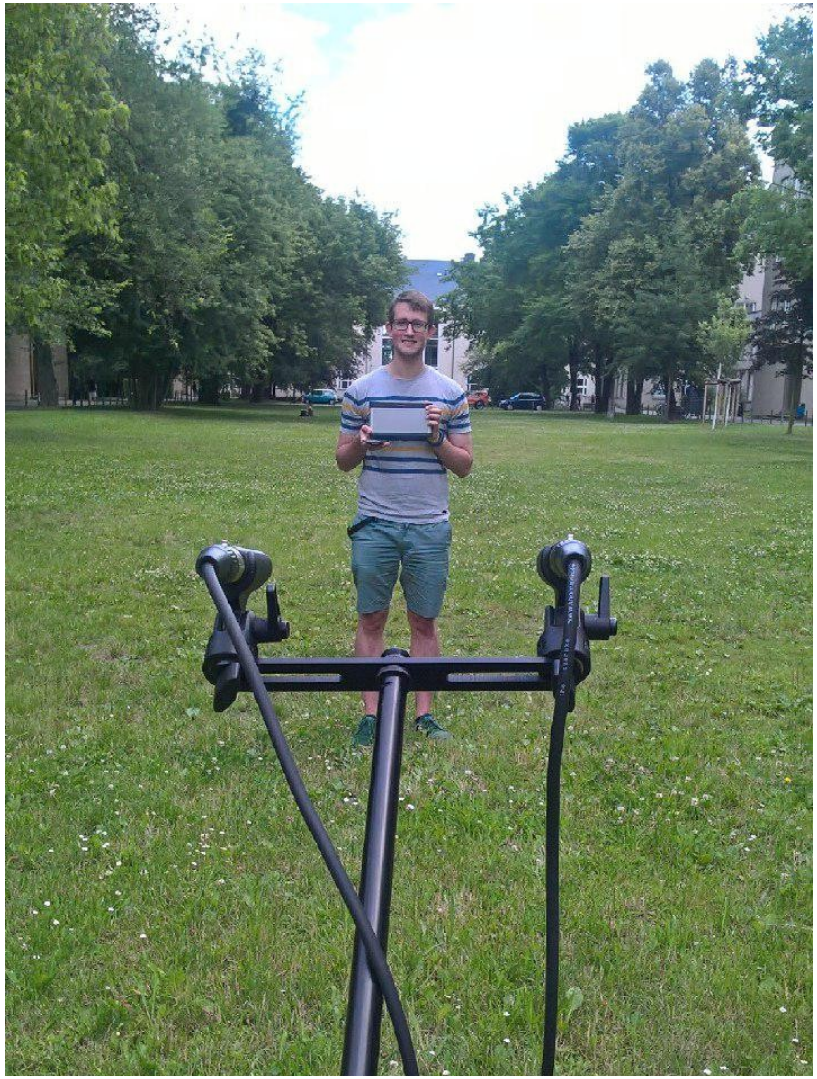
- modular and easily extendable
- processing lots of files
- concise output format

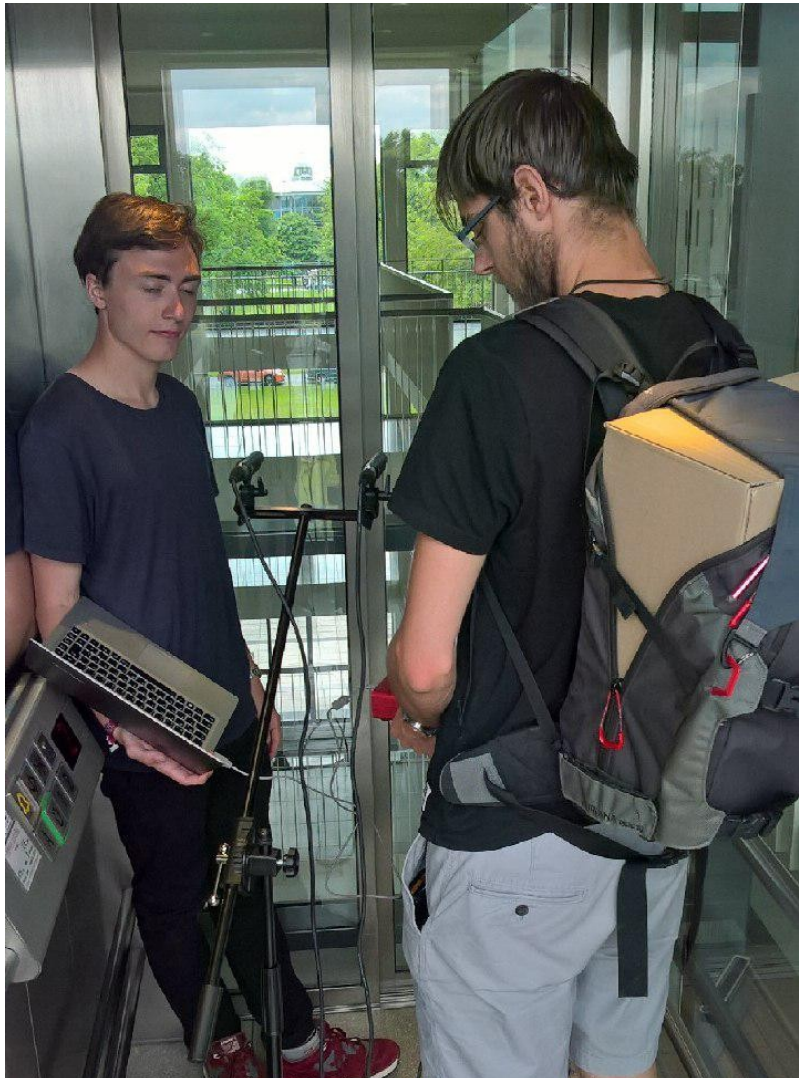
	A	B	C	D	E	F	G	H
1	File	duration	rate	ripple	sigma	exp	area	t_diff
2	lucas_bad_m_2_(4.3s)+0.1s	0,1	44100	0,212309356	0,000853538	1,08206545	0,3279235	-0,0003401
3	lucas_von_flur_in_bad_m_(4.3s)+0.1s	0,1	44100	0,176322991	0,000901402	0,95876285	0,3512552	-0,0002494
4	trefftz_fahrstuhl_m_(4.2s)+0.1s	0,1	44100	0,335269505	0,000982243	16,8825806	0,1860949	0,0001587
5	trefftz_oben_andere_seite_(4.1s)+0.1s	0,1	44100	0,45868271	0,001009181	53,6486072	0,1126305	0,0002948
6	lucas_bad_m_1_(4.4s)+0.1s	0,1	44100	0,268880279	0,001052943	5,28609622	0,3045759	-0,0003628
7	trefftz_oben_andere_seite_m_(4.4s)+0.1s	0,1	44100	0,315810482	0,001074258	49,1841885	0,1476927	0,0001587
8	trefftz_oben_andere_seite_(4.2s)+0.1s	0,1	44100	0,488886935	0,001081838	63,8264398	0,1023328	0,0001134
9	trefftz_unten_(4.2s)+0.1s	0,1	44100	0,500751228	0,001134545	74,3452605	0,0913474	0,0001587
10	trefftz_unten_(4s)+0.1s	0,1	44100	0,479571512	0,001176337	63,8861492	0,1023795	0,0002041
11	trefftz_oben_andere_seite_(4s)+0.1s	0,1	44100	0,487005541	0,001188431	59,9251996	0,0990409	0,0001361
12	lucas_bad_m_2_(4.1s)+0.1s	0,1	44100	0,354844946	0,001200515	49,7135661	0,1442596	-0,0003175
13	bruecke_hsz_strasse_parallel_(4.4s)+0.1s	0,1	44100	0,241628489	0,0012016	0,97980988	0,2601439	0,0001134
14	trefftz_oben_andere_seite_(4.3s)+0.1s	0,1	44100	0,410178066	0,001222456	39,8007037	0,1337623	0,0002268
15	trefftz_unten_(4.1s)+0.1s	0,1	44100	0,494284162	0,00122855	53,7368326	0,1010781	0,0001134
16	trefftz_oben_andere_seite_m_(4.2s)+0.1s	0,1	44100	0,318519645	0,001228612	33,7376753	0,1580059	0,0001361
17	trefftz_oben_andere_seite_m_(4.3s)+0.1s	0,1	44100	0,303908068	0,001295658	27,6095732	0,1701814	0,0002268
18	trefftz_oben_andere_seite_(4.4s)+0.1s	0,1	44100	0,460084415	0,00130693	58,4254738	0,1102786	0,0002268
19	trefftz_unten_(4.3s)+0.1s	0,1	44100	0,398273708	0,001376865	49,407999	0,1243118	6,8027E-05
20	bruecke_hsz_strasse_gegen_wand_(4.1s)+0.1s	0,1	44100	0,266531232	0,001674861	6,78608431	0,2299268	0,0335147
21	trefftz_fahrstuhl_m_(4.3s)+0.1s	0,1	44100	0,409191729	0,001800592	20,6389966	0,1430765	0,0002268
22	lucas_bad_m_2_(4.2s)+0.1s	0,1	44100	0,483991496	0,002283471	23,5545249	0,1385673	-0,0002268
23	lucas_bad_m_1_(4.2s)+0.1s	0,1	44100	0,428957288	0,002367564	18,2317763	0,1615128	-0,0001814
24	bruecke_hsz_strasse_gegen_wand_(4.3s)+0.1s	0,1	44100	0,276695186	0,002416416	7,64779262	0,2193418	0,0406349
25	bruecke_hsz_strasse_gegen_wand_(4.4s)+0.1s	0,1	44100	0,286712318	0,002609132	6,05203466	0,2190684	0,0001587
26	trefftz_fahrstuhl_m_(4.4s)+0.1s	0,1	44100	0,339297442	0,002994404	18,9469269	0,1965691	0,0002494
27	trefftz_oben_(4s)+0.1s	0,1	44100	0,314482055	0,004028928	26,6547339	0,1768702	0,0003401
28	trefftz_oben_andere_seite_m_oben_(4.1s)+0.1s	0,1	44100	0,308697014	0,004200597	18,7613616	0,174365	0
29	trefftz_wiese_m_bewegt_(4.1s)+0.1s	0,1	44100	0,230104292	0,004263123	2,58330639	0,3708262	-0,0108617

Recorded Signals



Recorded Signals





Recorded Signals

Recorded Signals

- Cardioid characteristic not omnidirectional characteristic
- Without primarily sound source low SNR
- With sound source less informations about the room characteristic
- Gauß-fit useful at ripple-factor > 0.3

Conclusion

- fairly simple models to classify correlation
- Octave tool for automated correlation of lots of data
- software can easily be extended with own models and analysis functions
- recorded enough audio material for about 500 sample signals
- compact excel spreadsheet for easy selection of test signals

»Wissen schafft Brücken.«