

FINGERPRINT Qualitätsmaße

Unter Kompression

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Überblick

- ▶ Unterschied Bildqualität / Kompressionsqualität
- ▶ Qualitätsmaße zwischen Zwei Bildern / Einem Bild
- ▶ Was wurde umgesetzt?
- ▶ Ergebnisinterpretation



Ziele

Gibt es Qualitätsmaße, mit denen man auf die Qualität **der
Kompression** schließen kann?

Qualitätsindizes in Korrelation zum NIST Matcher



Ablauf



Qualität des Abdruckes



Qualität der Kompression



Qualität des Abdruckes?



Hohe Qualität



Schlechte Qualität



Qualität der **Kompression**?



Qualität der Komprimierung optisch nicht erkennbar



Qualitätsmaße

- ▶ Zwischen 2 Abdrücken



- ▶ Mit nur einem Abdruck



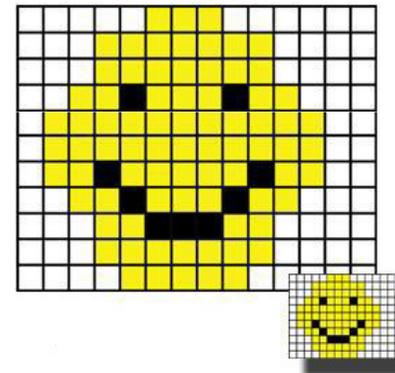
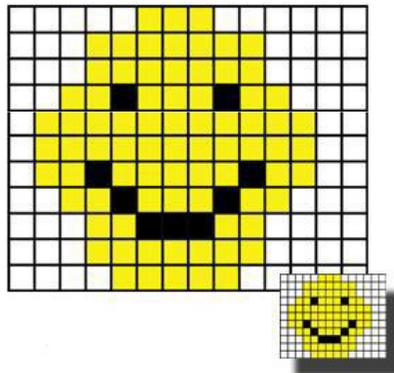
Qualitätsmaße zwischen **zwei** Bildern

- ▶ MSE
- ▶ PSNR
- ▶ PMSE
- ▶ LMSE
- ▶ LP-Norm
- ▶ Kreuzkorrelation



Mittlere quadratische Abweichung

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \|I(i,j) - K(i,j)\|^2$$

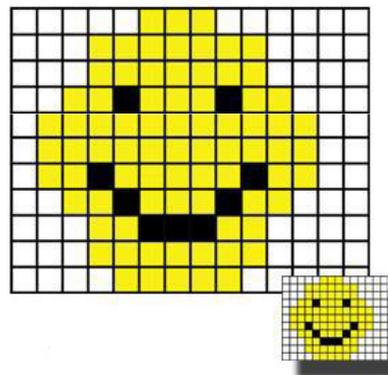
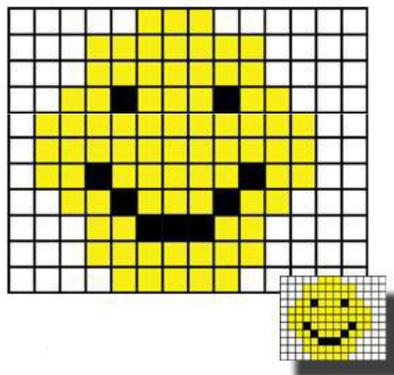


$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right) = 20 \cdot \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right)$$



Mittlere quadratische Abweichung cont'd

$$\text{PMSE} = \frac{1}{MN} \sum_{j=1}^M \sum_{k=1}^N [F(j,k) - \hat{F}(j,k)]^2 / [\text{Max}\{F(j,k)\}]^2$$



$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

$$\text{LMSE} = \sum_{i=1}^{M-1} \sum_{k=2}^{N-1} [O\{F(j,k)\} - O\{\hat{F}(j,k)\}]^2 / \sum_{j=1}^{M-1} \sum_{k=2}^{N-1} [O\{F(j,k)\}]^2$$



LP - Norm

$$L_p = \left\{ \frac{1}{MN} \sum_{j=1}^M \sum_{k=1}^N |F(j,k) - \hat{F}(j,k)|^p \right\}^{1/p}, p = 1, 2, 3$$

L1 Norm: Manhattan Metrik / Taximetrik

L2 Norm: Euklidischer Abstand

...
Lp

Korrelation

$$NK = \frac{\sum_{j=1}^M \sum_{k=1}^N F(j,k) \hat{F}(j,k)}{\sum_{j=1}^M \sum_{k=1}^N [F(j,k)]^2}$$

▶ Soll gute Ergebnisse liefern

Qualitätsmaße

- ▶ Zwischen 2 Abdrücken



- ▶ Mit nur einem Abdruck



Qualitätsmaße mit nur **einem** Abdruck

- ▶ Nist QI
- ▶ Frequency Domain
- ▶ Spatial Domain

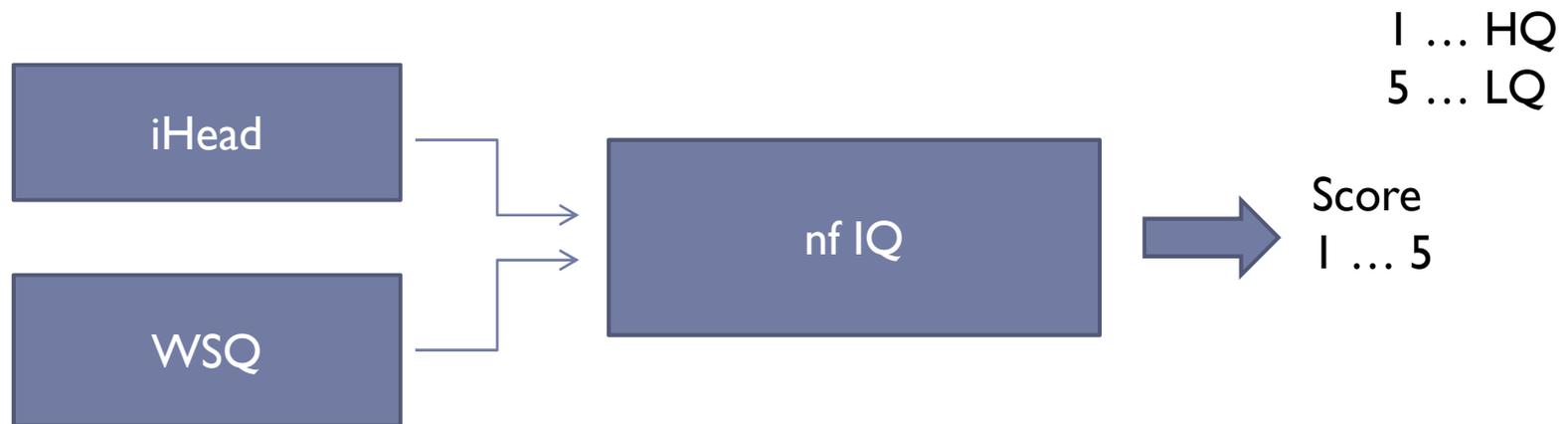


NIST Quality Index

```
NAME
    nfiq - evaluates a fingerprint image and returns a quality value for the image on a scale of 1
    (highest quality) to 5 (lowest quality).

SYNOPSIS
    nfiq <fingimage in>

DESCRIPTION
    Nfiq takes as input a file containing a fingerprint image. The image file can be in ANSI/NIST or
    NIST IHEAD format or compressed with WSQ, baseline JPEG, or lossless JPEG compression. nfiq uses
    the image maps generated by mindtct to create a feature vector for the image which is passed to an
    multi-layer perceptron (MLP) neural network. The MLP NN returns an activation value that is used
    to rank the images quality on a scale of 1 (highest quality) to 5 (lowest quality).
```

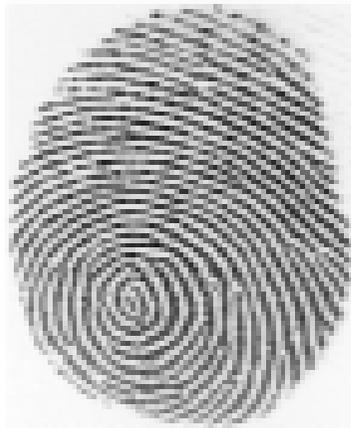


NIST Quality Index

- ▶ Minutenbasiert
- ▶ Blockbasierter NIST Minutendetector (mindtct)
- ▶ Input Vektor mit 11 Parametern
- ▶ Neuronales Netz klassifiziert auf 5 Werte
- ▶ NN: 3 Layer, Nichtlineares Perceptron



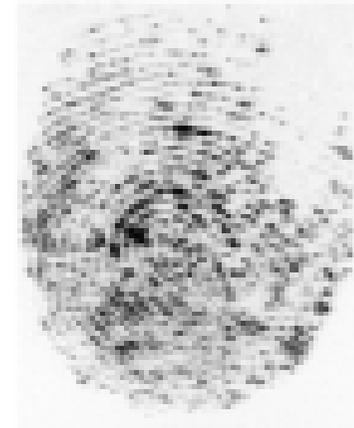
Frequenzbereich (Frequency Domain)



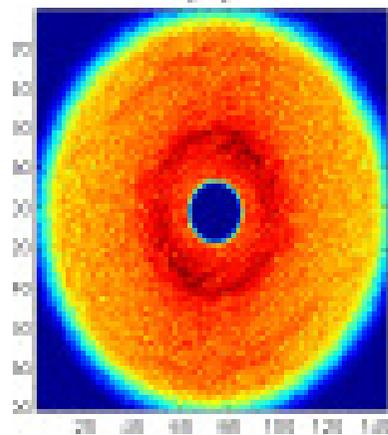
(a)



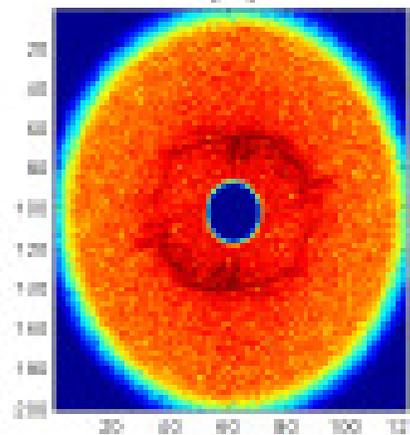
(b)



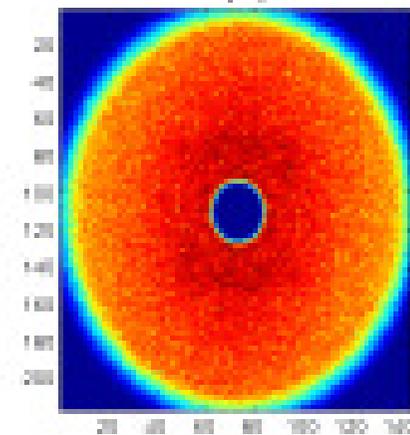
(c)



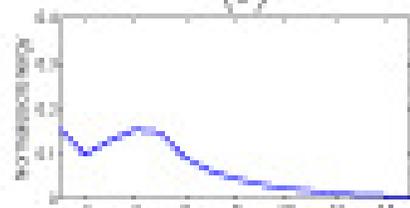
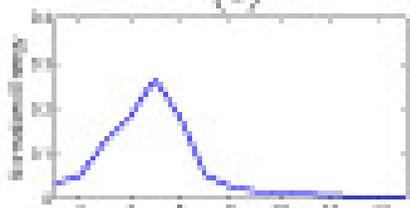
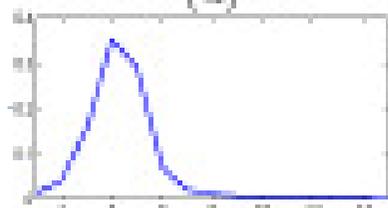
(d)



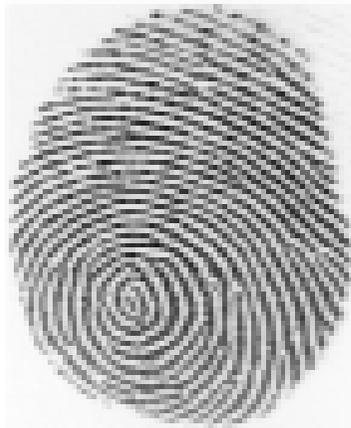
(e)



(f)



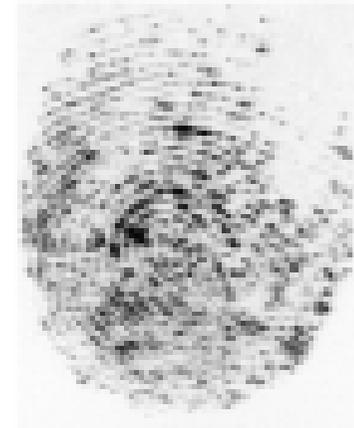
Frequenzbereich (Frequency Domain)



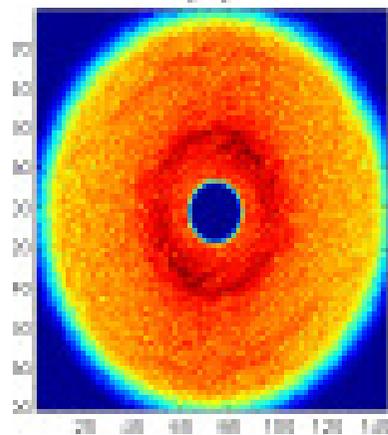
(a)



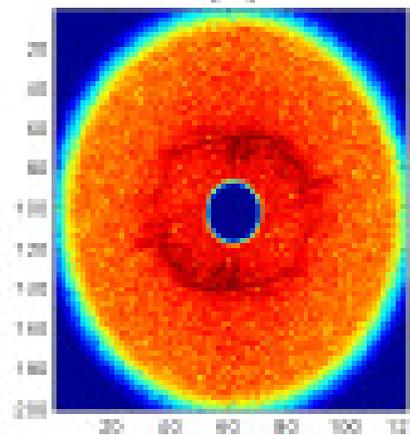
(b)



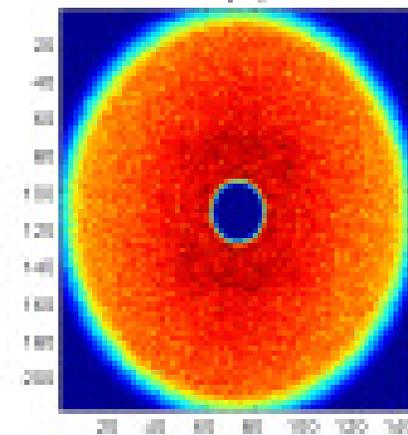
(c)



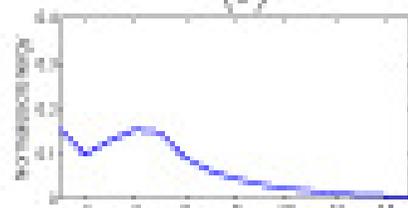
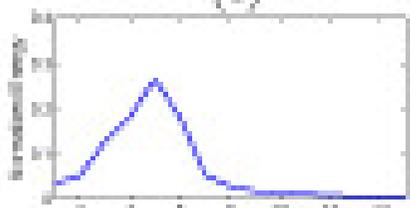
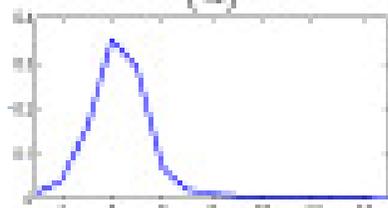
(d)



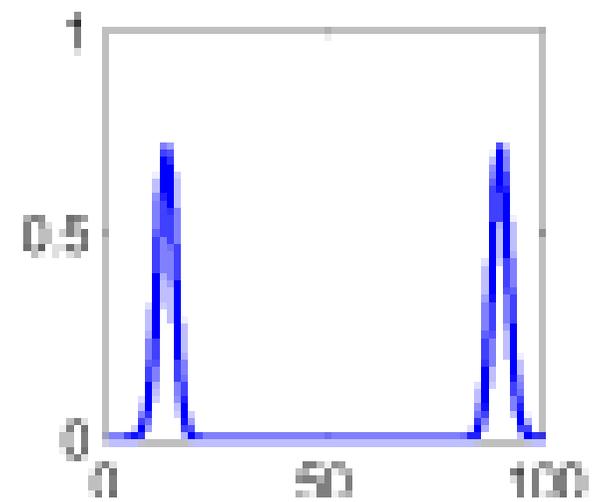
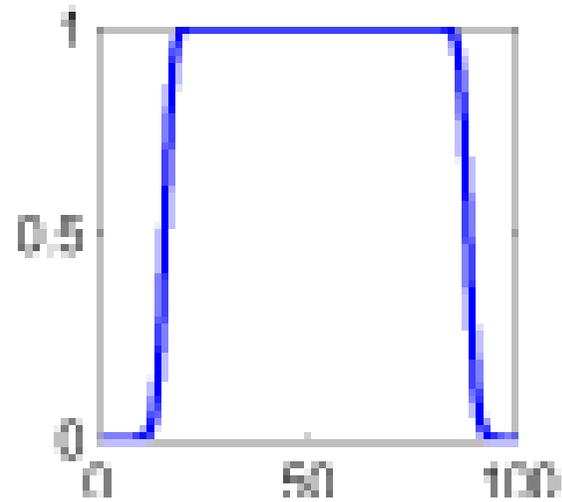
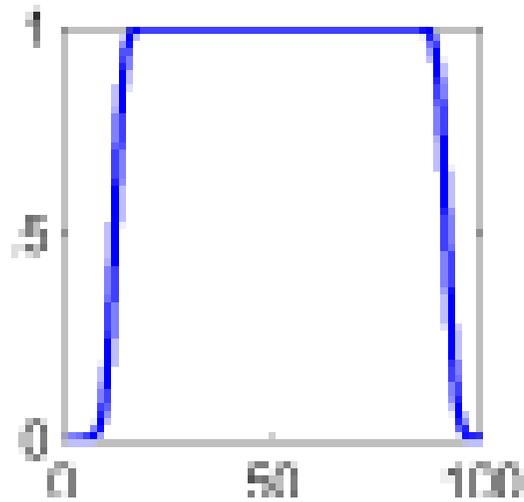
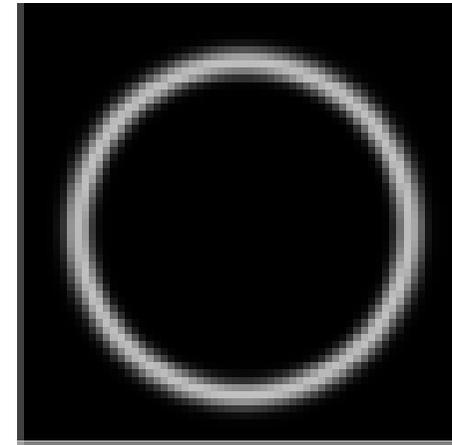
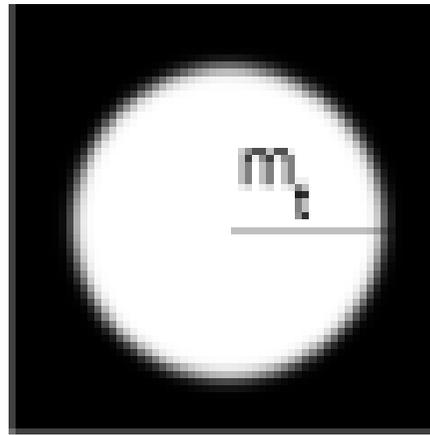
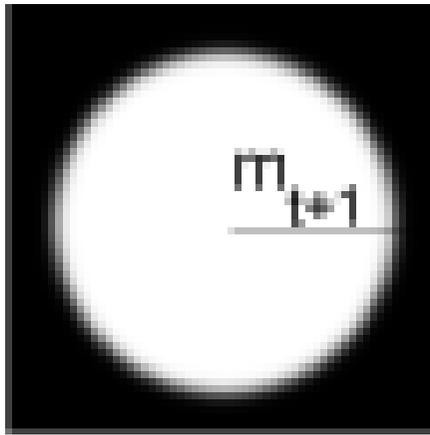
(e)



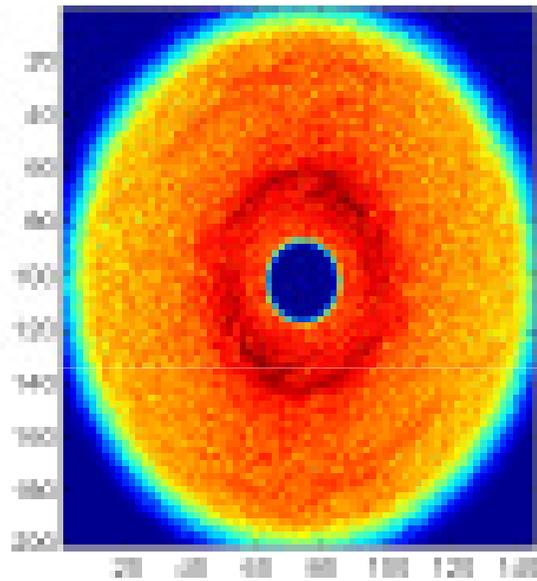
(f)



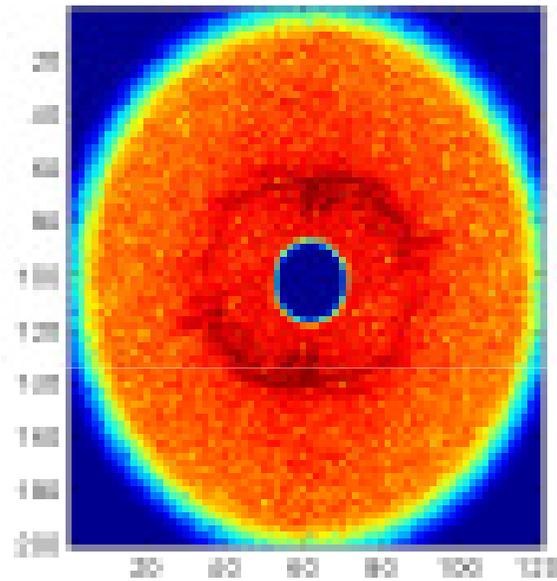
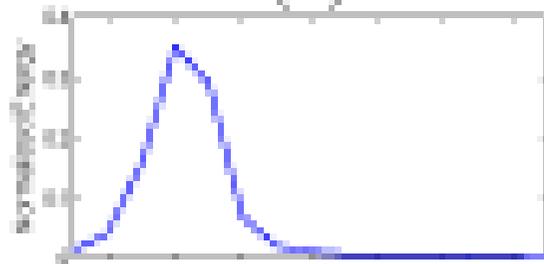
Frequency Domain cont'd



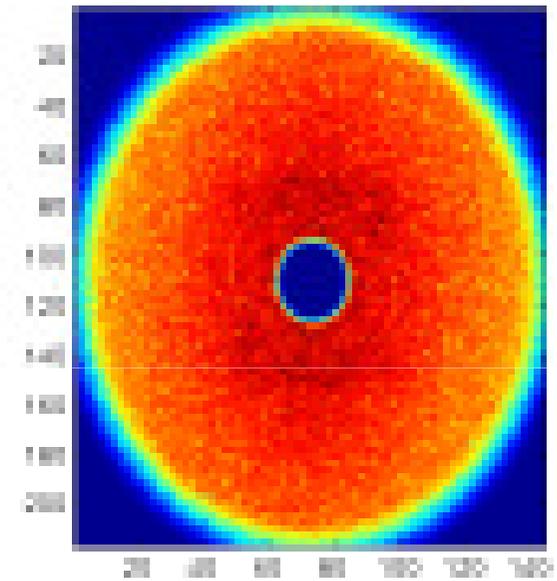
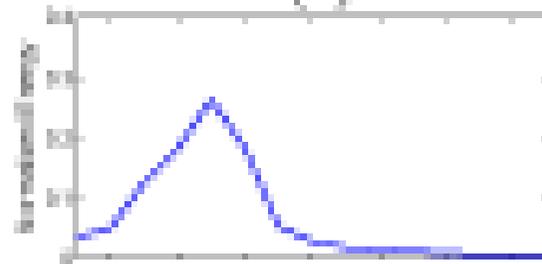
Frequency Domain



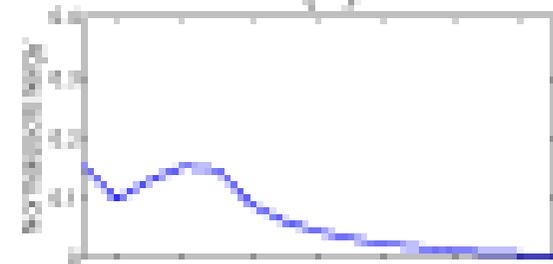
(d)



(e)



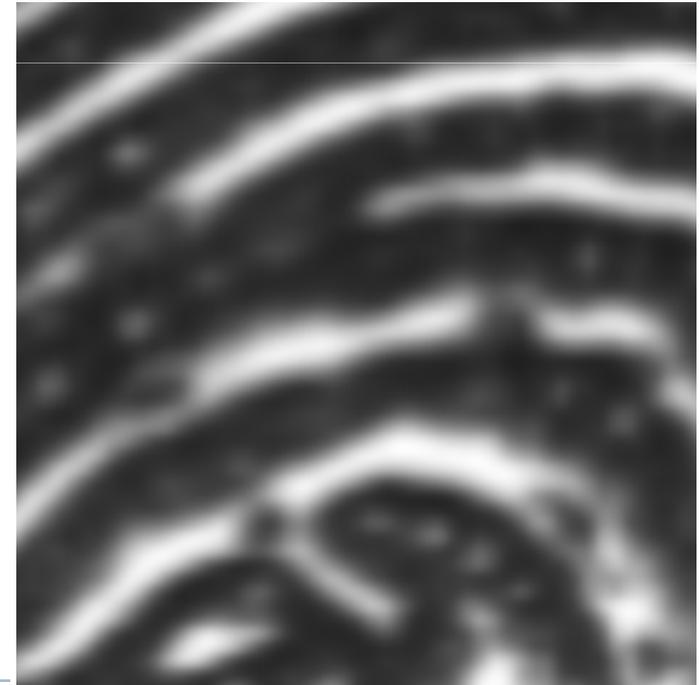
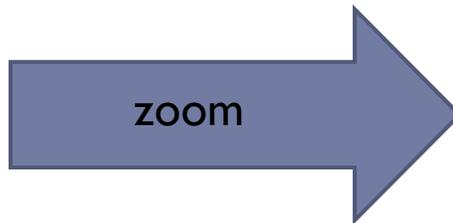
(f)



Bildbereich



- ▶ Blockorientiert
- ▶ Vordergrundabstraktion
- ▶ Klarheit durch Gradientenverfahren



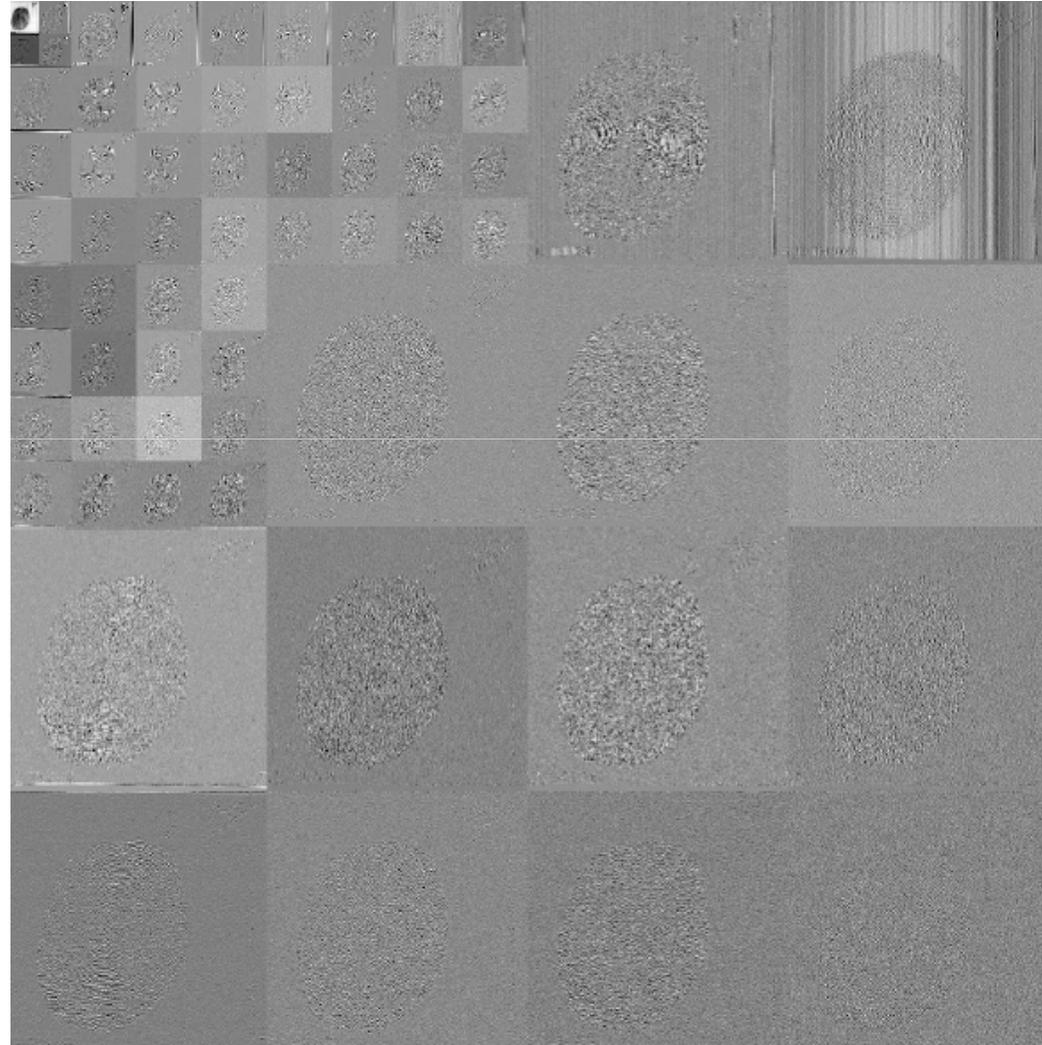
Anforderungen

- ▶ Baseline JPEG 6.0
- ▶ Jpeg 2000
- ▶ WSQ

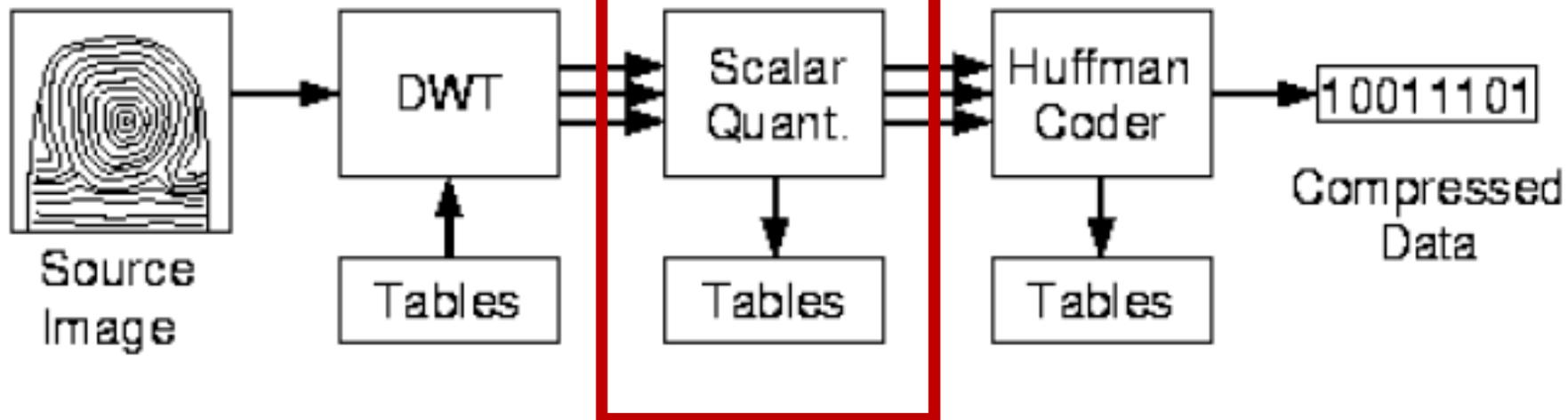


WSQ (Wavlet Scalar Quantization)

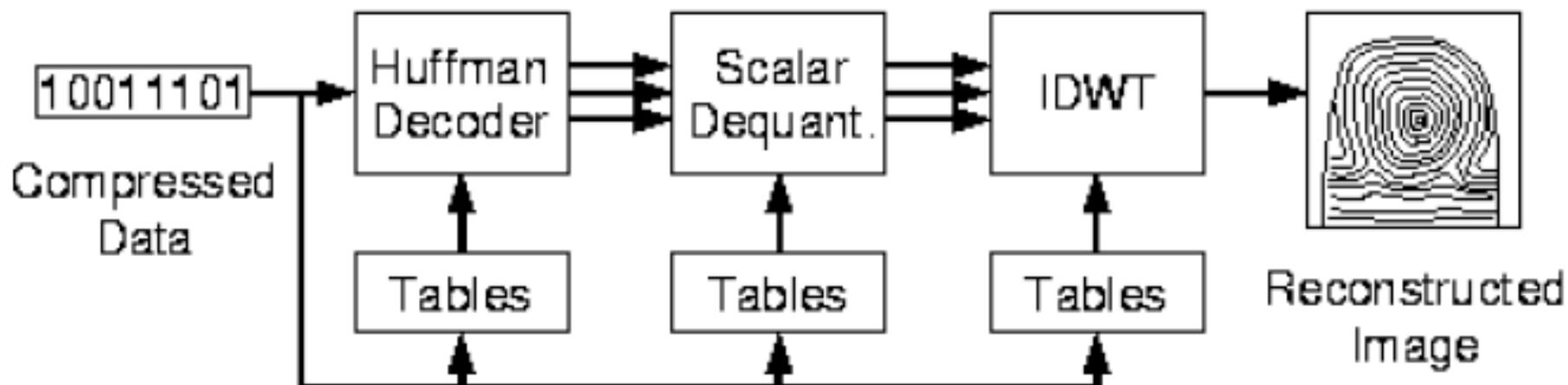
- ▶ Optimiert für Fingerabdrücke
- ▶ FBI Standardformat für Abdrücke
- ▶ NIST WSQ Encoder
- ▶ SDKs:



WSQ Encoder:



WSQ Decoder:



WSQ Eigenheit

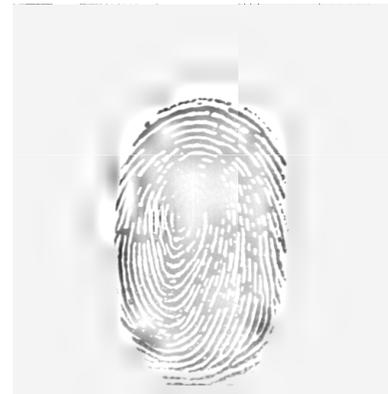
- ▶ WSQ erst ab 2:1 Sinnvoll, d.h. ab 50% Qualität
- ▶ Nist: bitrate=5.625



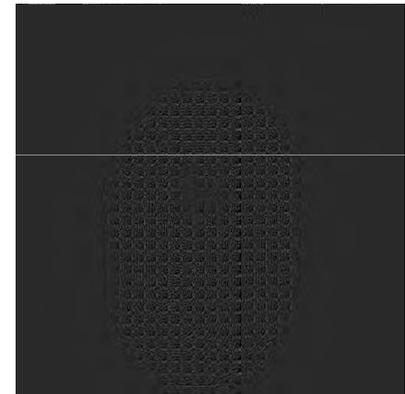
Original



Whirl Heavy
WSQ 50%



Whirl Heavy
WSQ 60%



Whirl Heavy
WSQ 100%



Auswahl der Abdrücke



Wirbel



verschmutzter Wirbel



Auswahl der Abdrücke cont'd



linksdrehend



rechtsdrehend



rechtsdrehend und schmutzig



Auswahl der Abdrücke cont'd



rechtsdrehende Welle



rechtsdrehend, geradlinig



geradlinige Welle



Kompressionskonfiguration

- ▶ Baseline JPG: 100×100 Pixels \times 8 Bit/Pixel = 10.000 Bytes
- ▶ 10% Baseline JPG gibt ca. 1.000bytes Dateigröße abzüglich Gewinn aus Entropie
- ▶ WSQ: bitrate:
r=2,25 entspricht 1:15
→ „100%“ ... r=11,25
- ▶ → „80%“ ... r=9
- ▶ ...



Ziel - Ergebnismatrix

- ▶ Jeder Abdruck

/	JPG/J2K/WSQ	JPG/J2K/WSQ2	...	JPG/J2K/WSQ3
	10%	20%		100%
MSE				
PSNR				
...				
FreqDom				



Implementierung :: Java

- ▶ MSE
- ▶ PSNR
- ▶ PMSE
- ▶ LMSE
- ▶ LP-Norm
- ▶ Kreuzkorrelation
- ▶ Frequency Domain
- ▶ Spatial DomainMSE
- ▶ PSNR
- ▶ PMSE
- ▶ LMSE
- ▶ LP-Norm
- ▶ Kreuzkorrelation



Nicht implementiert

- ▶ NIST QI
- ▶ NIST Matcher



.csv Dateien

	A	B	C	D	E	F	G	H	I
1	Directory	Filename	FreqDom	LPNorm	PMSE	LMSE	PSNR	NK	SpatDom
2	JPEG_6.0_040	LeftLoop_whirl.pgm	13.550.582.538.237.400	6.200.030.292.755.950	3,09E+11	0.3250976579	351.065.212.547.147	0.9991265785141512	0.326555256260326
3	JPEG_6.0_040	RightLoop_01.pgm	12.633.695.705.066.900	6.466.610.179.210.430	3,20E+12	0.3317200148	34.949.100.862.163.300	0.9990598539061506	1.632.538.579.197.800
4	JPEG_6.0_040	RightLoop_light.pgm	0.7690587588693525	5.277.319.946.150.140	1,44E+12	0.3293587940	3.841.368.048.956.400	0.9987493980348799	0.301170563792958
5	JPEG_6.0_040	RightLoop_messy.pgm	11.721.975.999.884.000	6.243.080.623.633.870	2,87E+11	0.3343730754	3.541.756.875.662.500	0.9992969880556212	3.930.190.927.407.080
6	JPEG_6.0_040	RightLoop_wave.pgm	12.833.506.490.667.900	6.580.172.597.741.720	3,21E+11	0.2569973110	3.493.274.156.779.070	0.998385866770046	0.8595665084037696
7	JPEG_6.0_040	Straight_loop.pgm	1.271.349.409.664.940	5.822.661.141.307.310	2,30E+12	0.3350134338	3.638.190.767.208.240	0.9992443386597784	5.258.537.409.288.350
8	JPEG_6.0_040	Wave_01.pgm	10.702.963.050.766.000	6.168.571.009.724.110	2,84E+11	0.3250770292	3.546.497.653.453.690	0.9992161701849763	0.17274276224501847
9	JPEG_6.0_040	Whirl_01.pgm	10.334.891.803.264.800	6.141.833.427.063.680	3,22E+11	0.3652236870	34.919.765.111.074.300	0.9991287260171267	5.926.562.818.538.190
10	JPEG_6.0_040	Whirl_heavy.pgm	11.641.122.936.121.400	5.384.865.593.155.200	1,98E+12	0.2950237200	3.704.062.684.466.260	0.9995479590943609	12.445.571.173.922.300
11	JPEG_2000_080	LeftLoop_whirl.pgm	1.385.189.462.480.430	18.920.326.669.116.300	3,03E+10	0.0273376357	4.519.176.835.875.040	0.9992641971751544	0.3448924724269797
12	JPEG_2000_080	RightLoop_01.pgm	13.152.674.576.482.500	18.281.417.407.822.400	2,66E+11	0.0225004912	45.744.200.080.164	0.9993568463710611	22.855.942.263.951.100
13	JPEG_2000_080	RightLoop_light.pgm	0.7906707118987764	13.662.134.218.109.300	1,09E+11	0.0180091452	4.964.084.838.413.100	0.9995606657799055	0.8779312764535551

- ▶ Vorteile:
Per BASH Script leicht erzeugbar
NIST QI leicht anhängbar