Mean Squared Error: Love It or Leave It? A New Look at Signal Fidelity Measures

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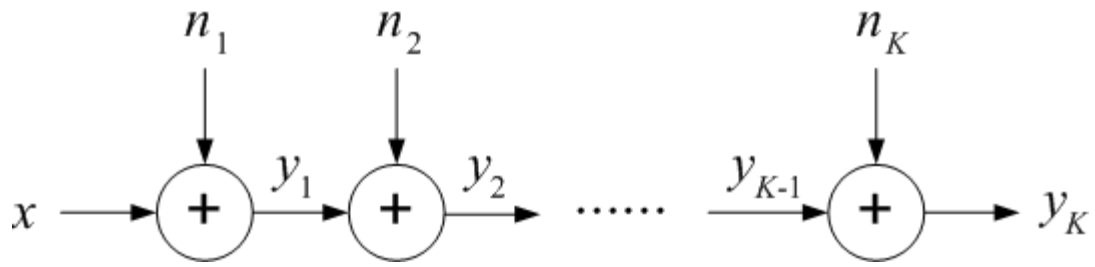


Fig. 1

(a) MSE=0, SSIM=1
CW-SSIM=1

(b) MSE=306, SSIM=0.928
CW-SSIM=0.938

(c) MSE=309, SSIM=0.987
CW-SSIM=1.000

(d) MSE=309, SSIM=0.576
CW-SSIM=0.814

(e) MSE=313, SSIM=0.730
CW-SSIM=0.811

(f) MSE=309, SSIM=0.580
CW-SSIM=0.633

(g) MSE=308, SSIM=0.641
CW-SSIM=0.603

(h) MSE=694, SSIM=0.505
CW-SSIM=0.925

(i) MSE=871, SSIM=0.404
CW-SSIM=0.933

(j) MSE=873, SSIM=0.399
CW-SSIM=0.933

(k) MSE=590, SSIM=0.549
CW-SSIM=0.917

(l) MSE=577, SSIM=0.551
CW-SSIM=0.916

Fig. 2

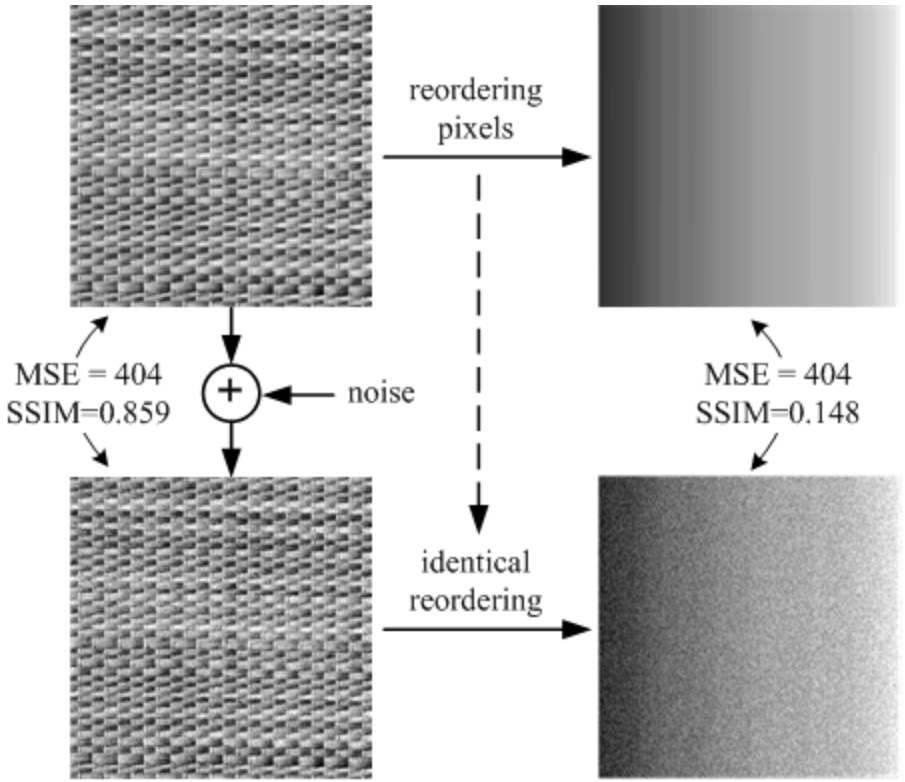

reordering
pixels
MSE = 404
SSIM=0.859
noise
MSE = 404
SSIM=0.148
identical
reordering

Fig. 3(a)

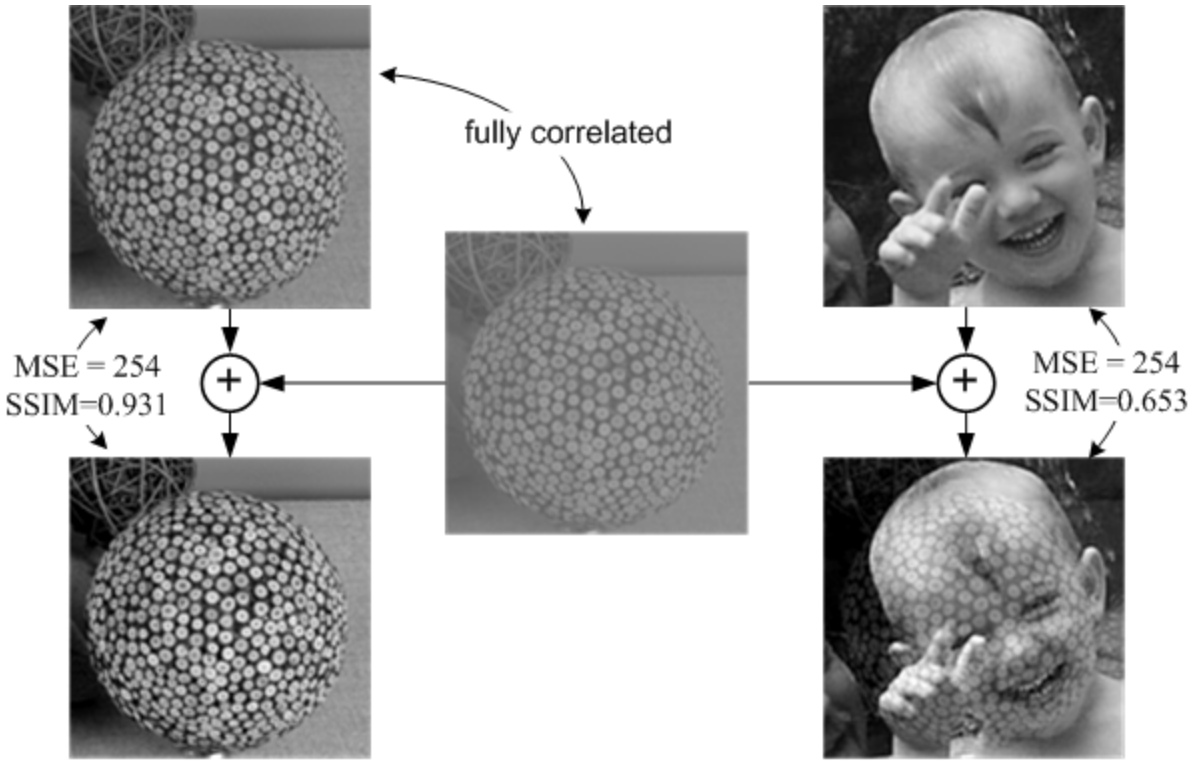


Fig. 3(b)

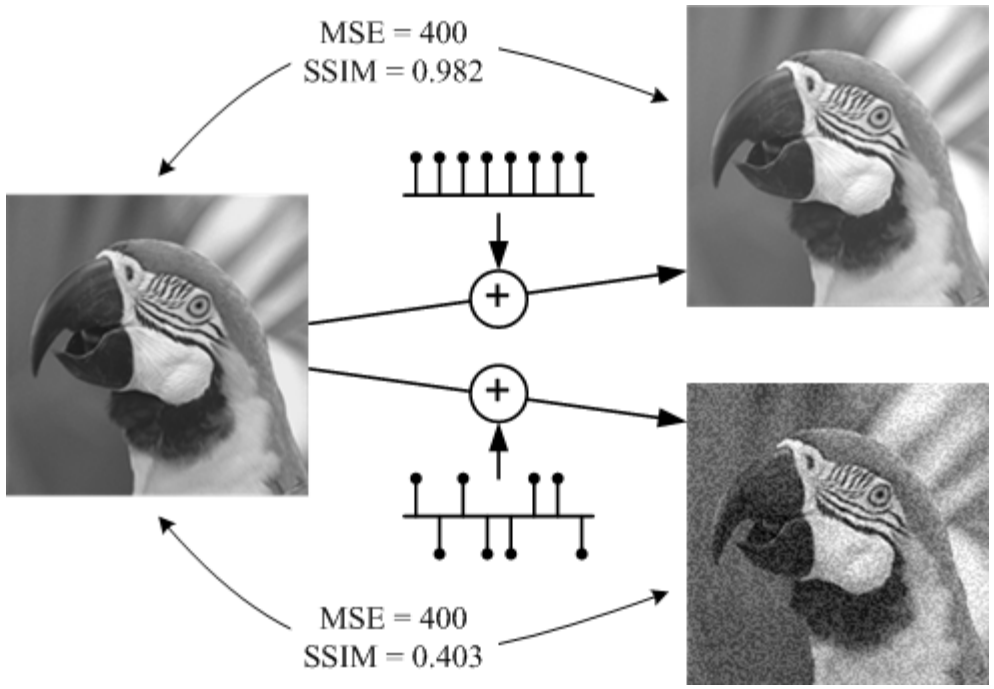


Fig. 3(c)

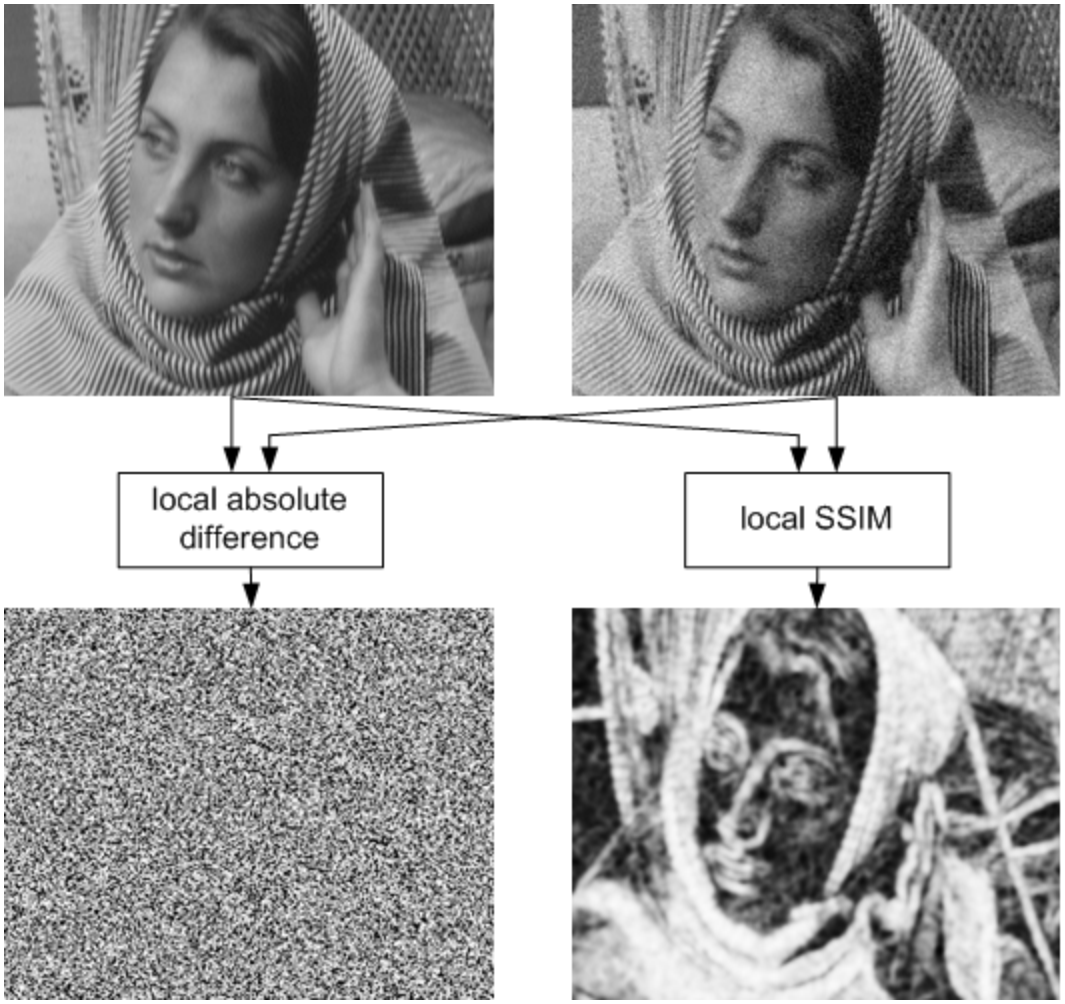


Fig. 3(d)

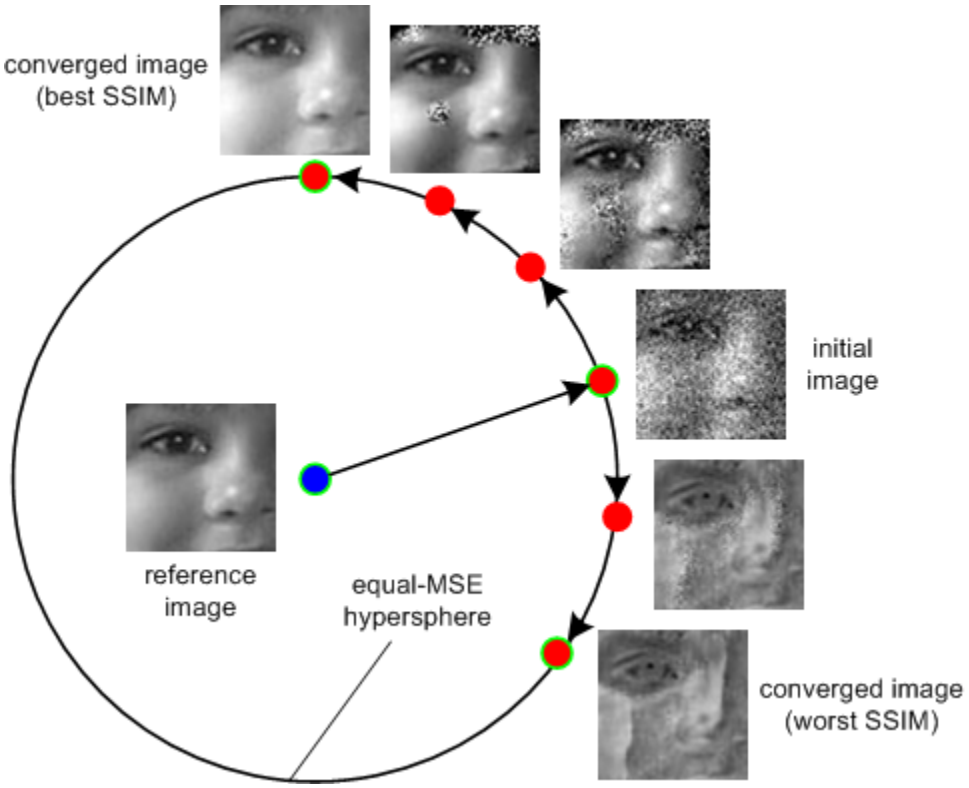

converged image
(best SSIM)
initial
image
reference
image
equal-MSE
hypersphere
converged image
(worst SSIM)

Fig. 4

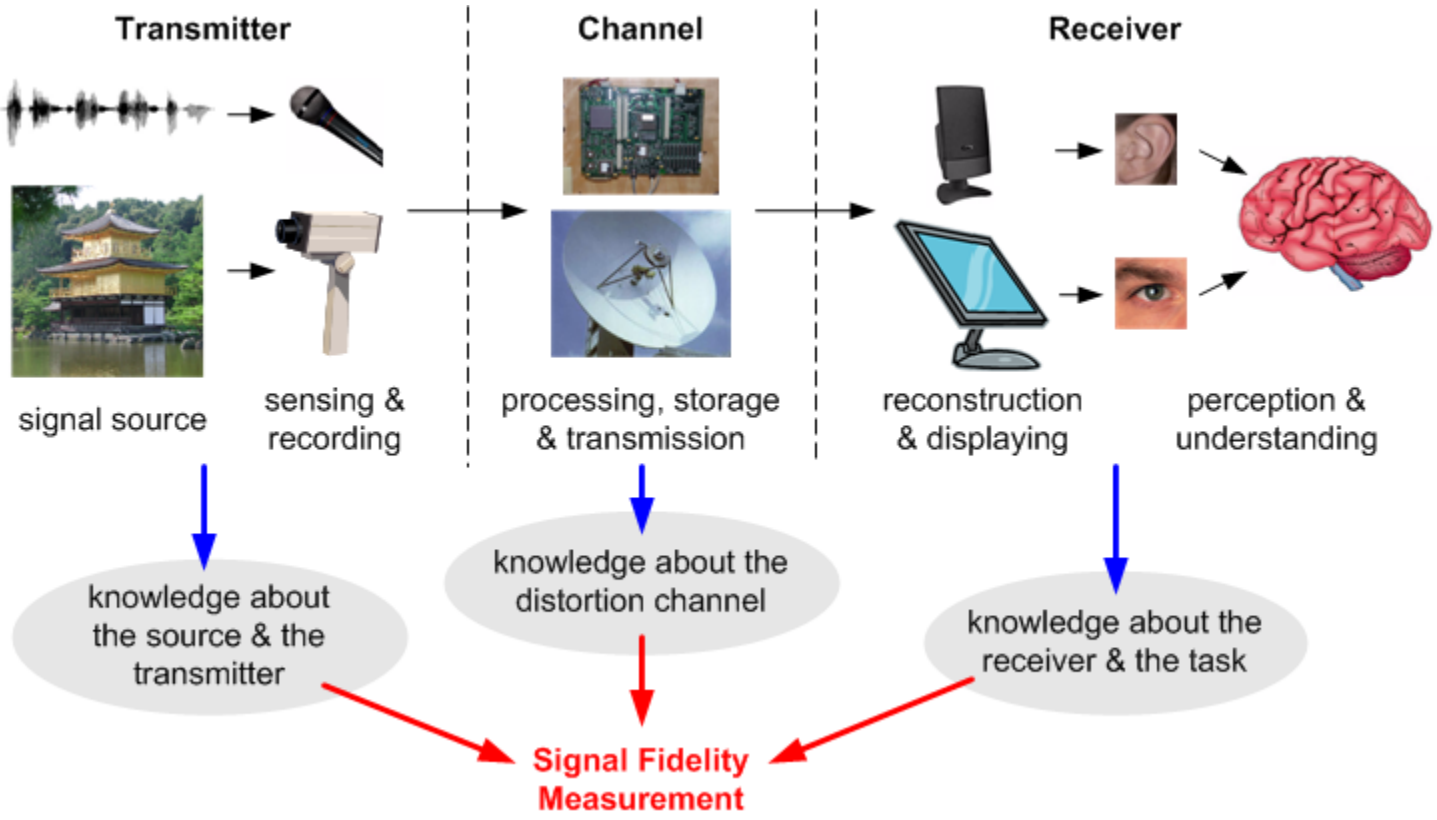

Transmitter
Channel
Receiver
signal source
sensing & recording
processing, storage & transmission
reconstruction & displaying
perception & understanding
knowledge about the source & the transmitter
knowledge about the distortion channel
knowledge about the receiver & the task
Signal Fidelity Measurement

Fig. 5

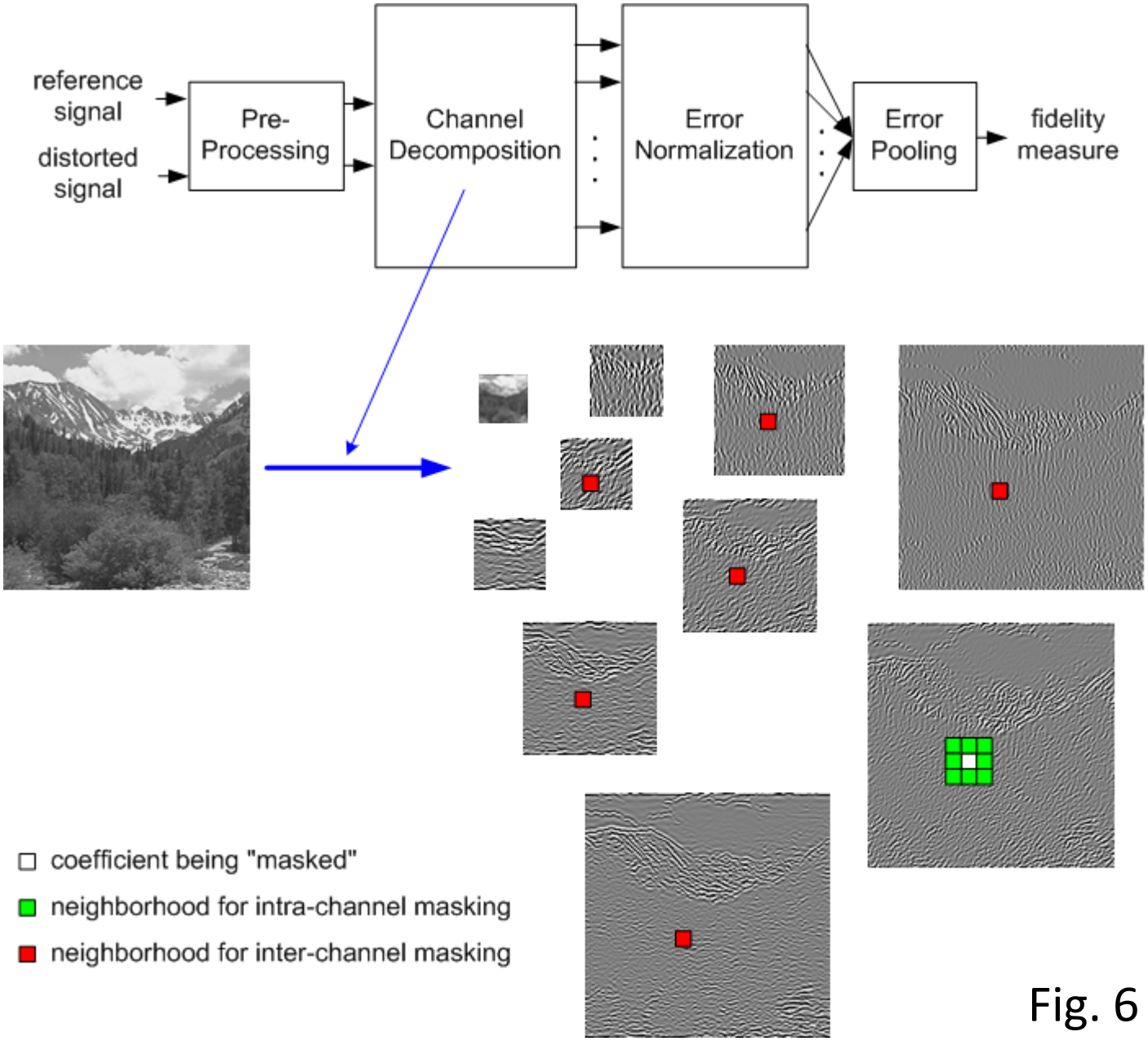

reference signal
distorted signal
Pre-Processing
Channel Decomposition
Error Normalization
Error Pooling
fidelity measure
coefficient being "masked"
neighborhood for intra-channel masking
neighborhood for inter-channel masking

Fig. 6

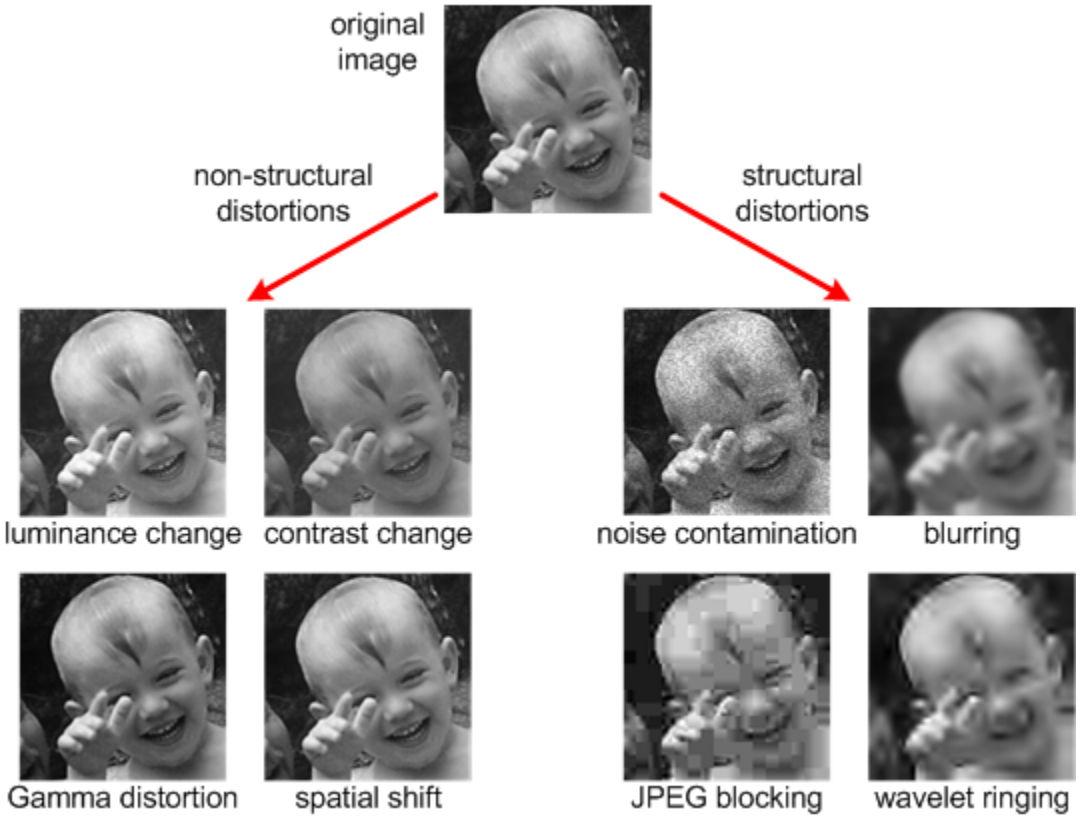

original image
non-structural distortions
structural distortions
luminance change
contrast change
noise contamination
blurring
Gamma distortion
spatial shift
JPEG blocking
wavelet ringing

Fig. 7

Fig. 8

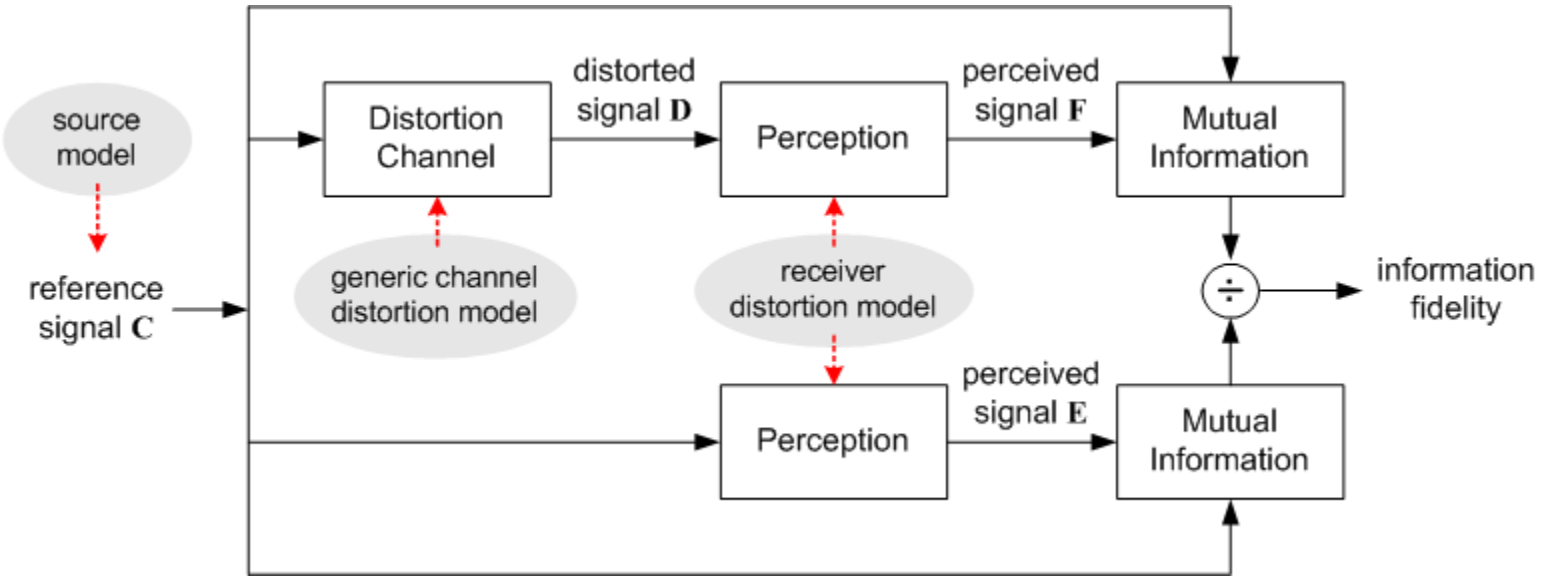

source model
reference signal C
Distortion Channel
distorted signal D
Perception
perceived signal F
Mutual Information
generic channel distortion model
receiver distortion model
÷
information fidelity
Perception
perceived signal E
Mutual Information

Fig. 9

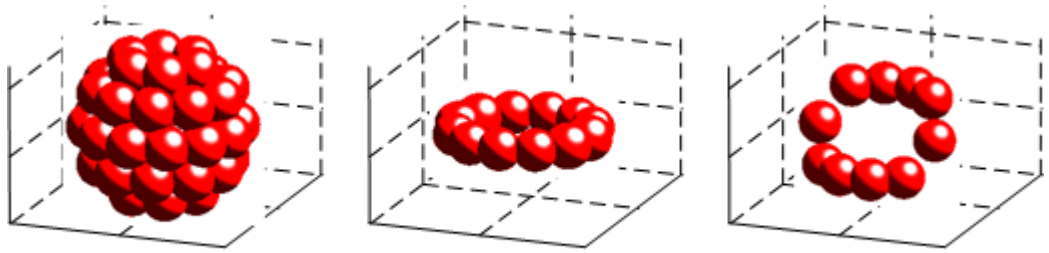


Fig. 10

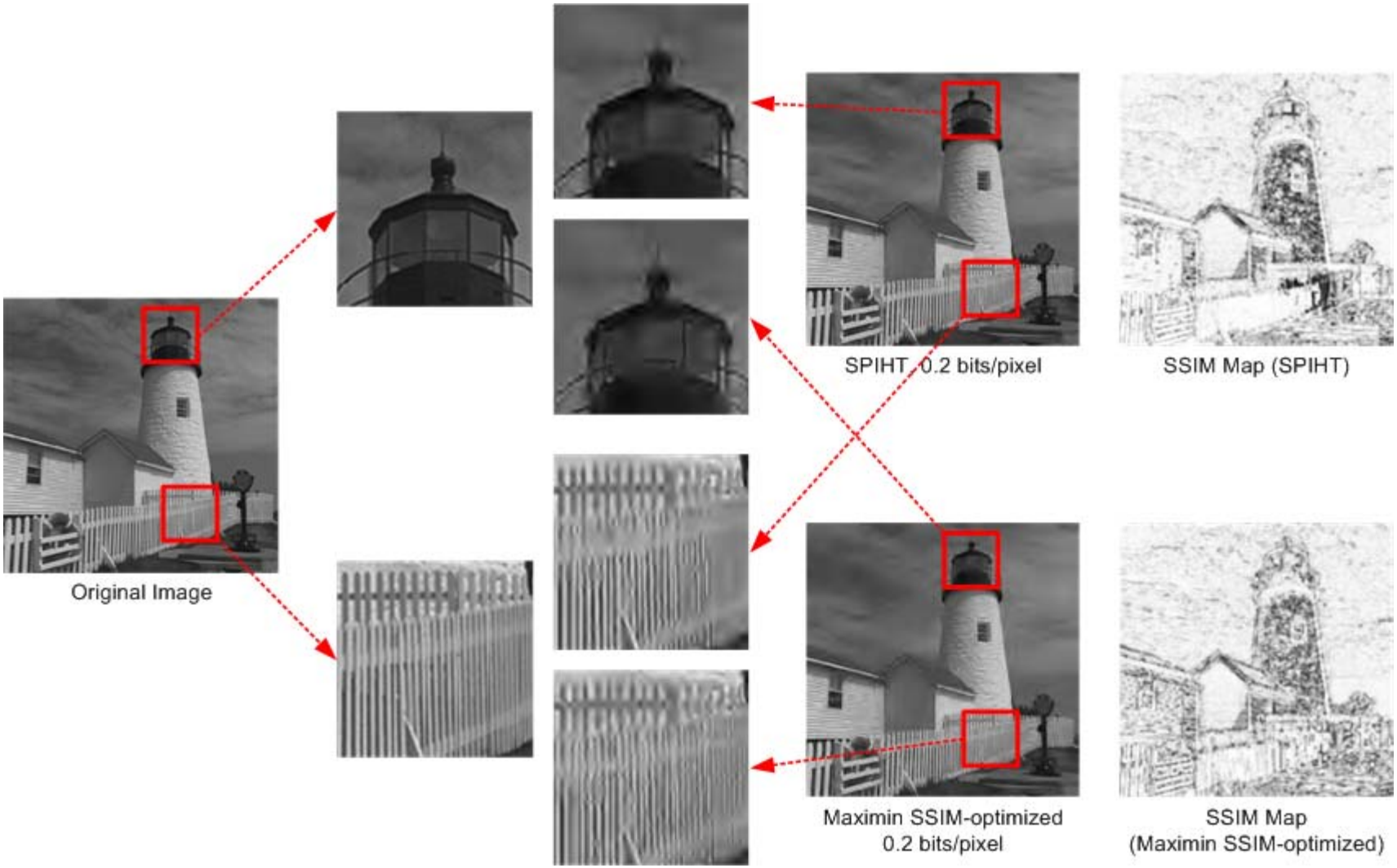

Original Image
SPIHT, 0.2 bits/pixel
SSIM Map (SPIHT)
Maximin SSIM-optimized
0.2 bits/pixel
SSIM Map
(Maximin SSIM-optimized)

Fig. 11

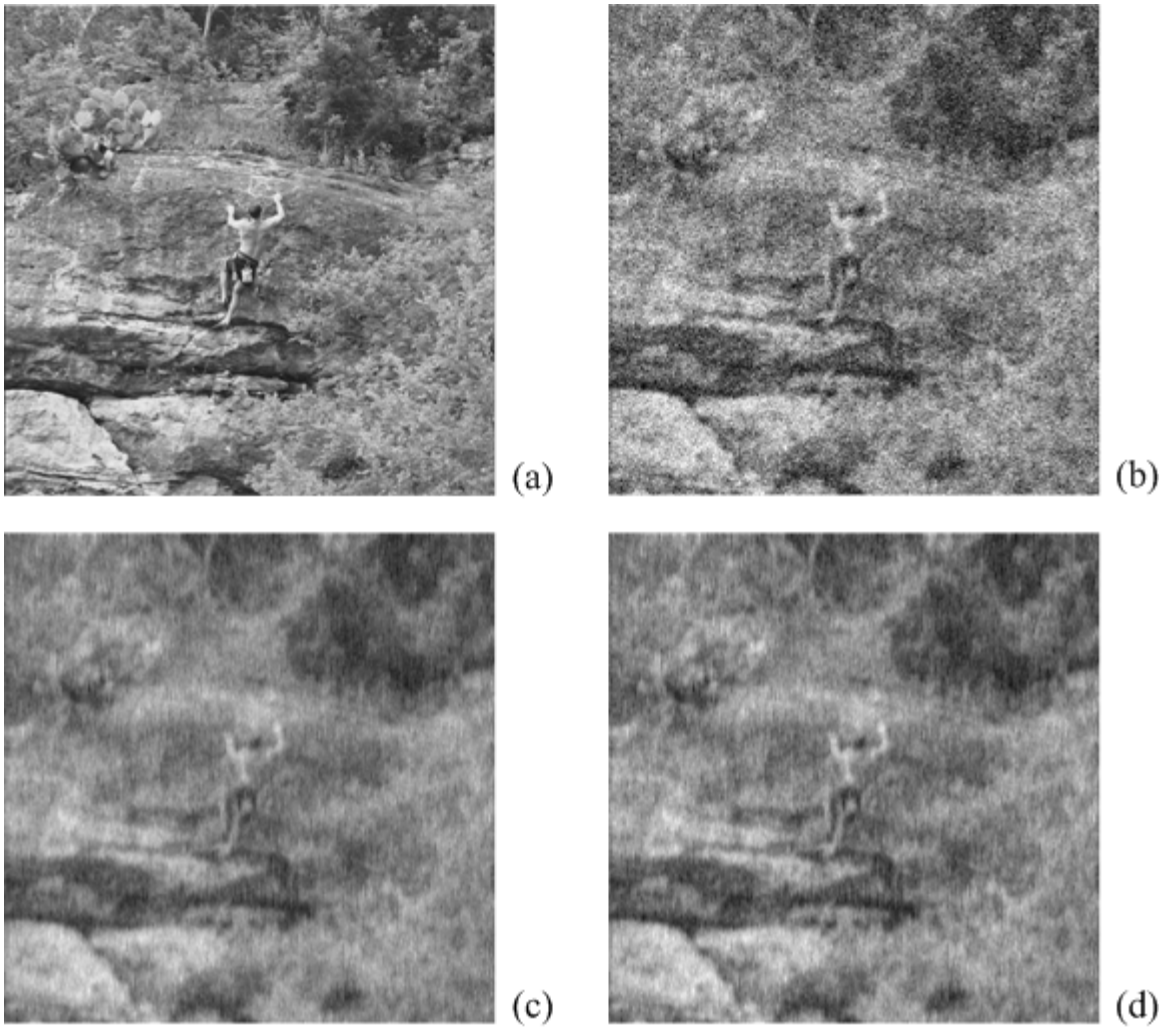
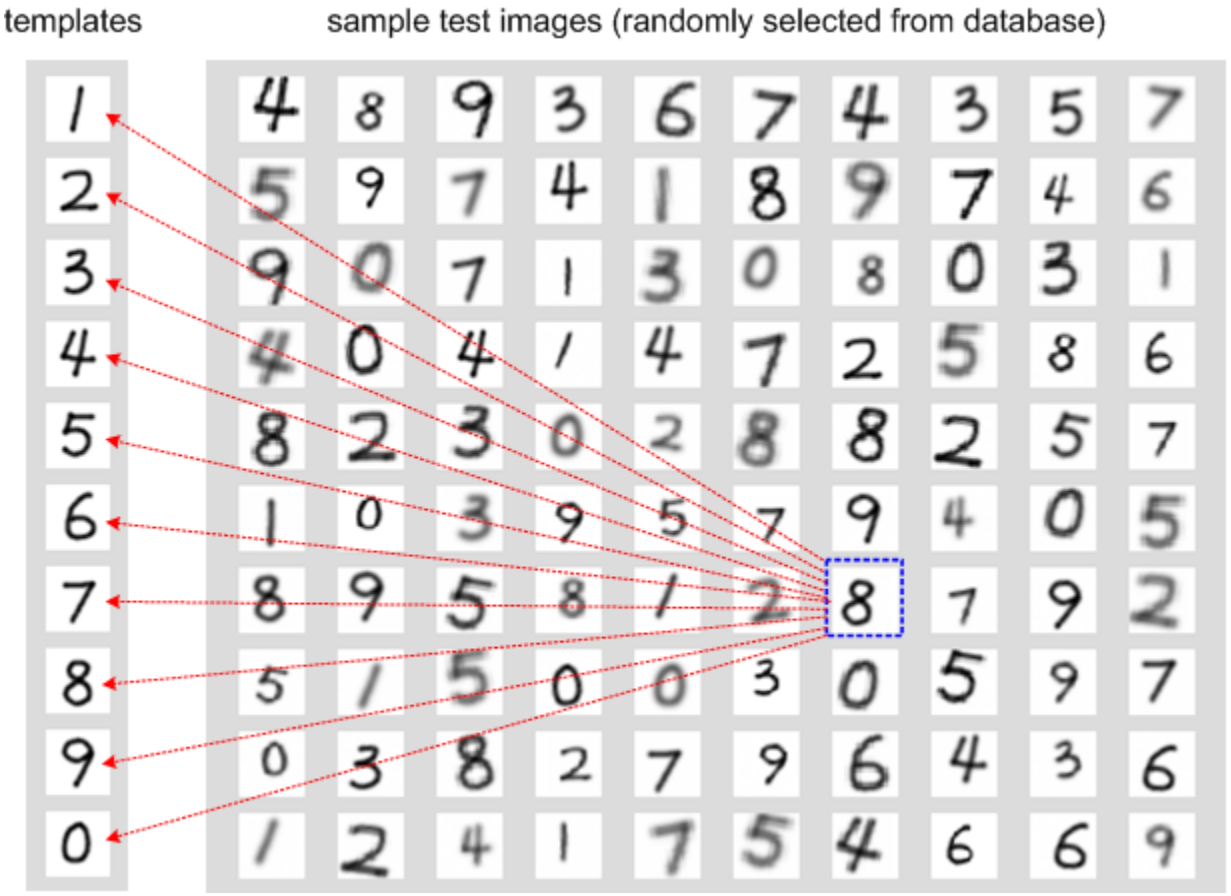


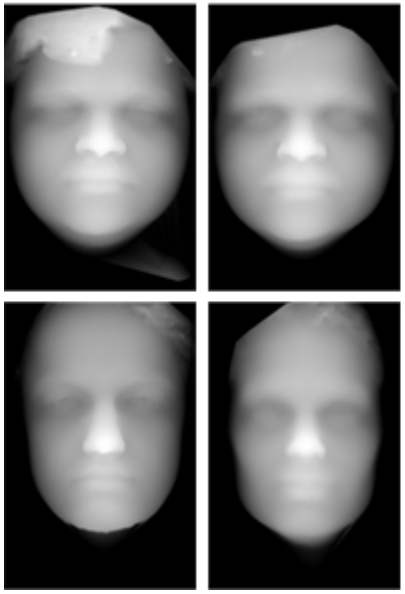
Fig. 12



recognition error rate (%)

digit	MSE	CW-SSIM
1	16.0	0
2	34.6	1.6
3	50.6	2.9
4	36.2	0
5	52.3	3.7
6	43.6	2.1
7	31.7	5.8
8	50.2	0.4
9	40.7	0
0	48.6	7.0
all	40.4	2.3

Fig. 13



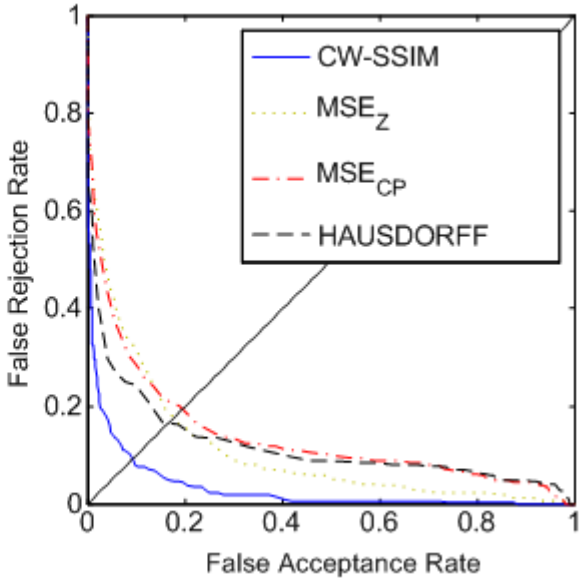

CW-SSIM
MSE_Z
MSE_CP
HAUSDORFF
False Rejection Rate
False Acceptance Rate
0
0.2
0.4
0.6
0.8
1

Fig. 14

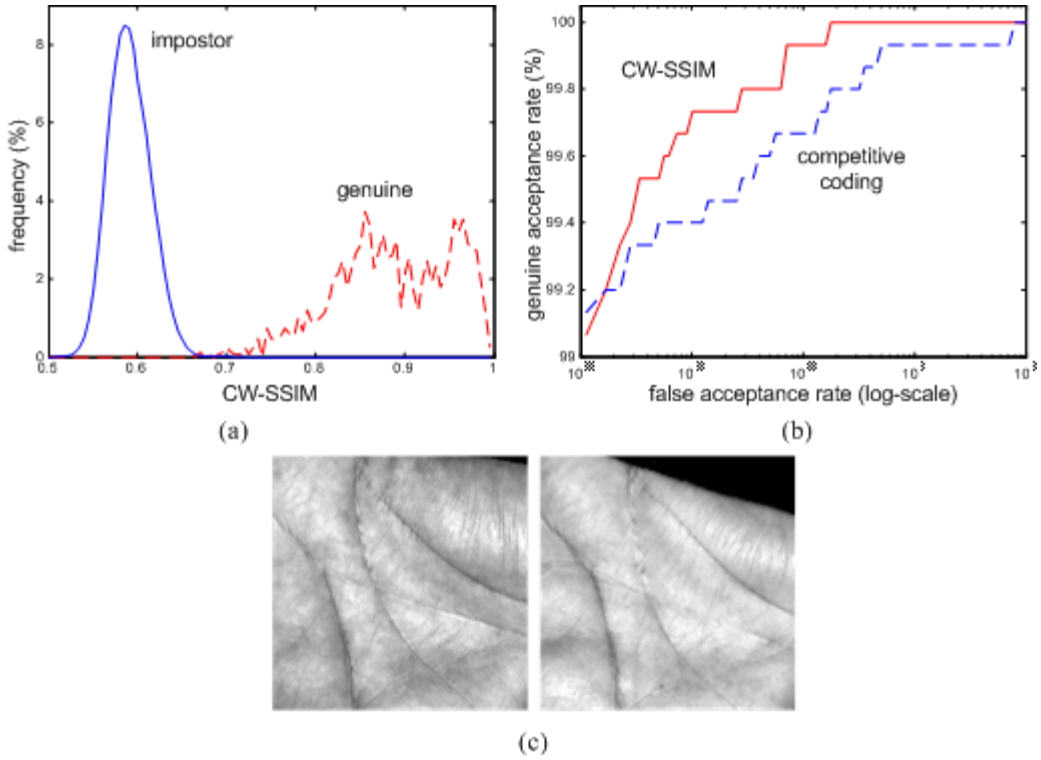

impostor
genuine
frequency (%)
CW-SSIM
(a)
CW-SSIM
competitive
coding
genuine acceptance rate (%)
false acceptance rate (log-scale)
(b)
(c)

Fig. 15