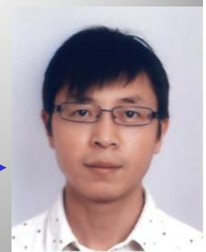
1

Video Enhancement

2 **Image enhancement**

- Noise/artifacts
- Contrast
- Color
- Sharpness



Not about recovering truth → image restoration

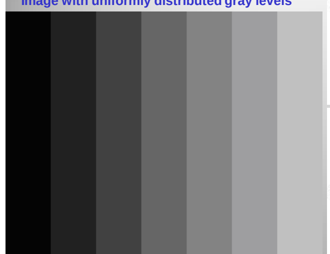
Subjectively more beautiful → image enhancement

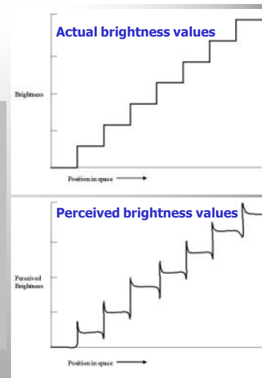
3

Sharpness enhancement

4 **The Mach band effect**

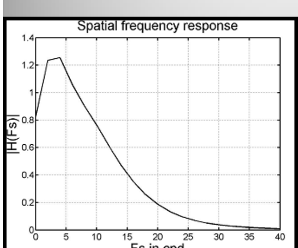
Image with uniformly distributed gray levels

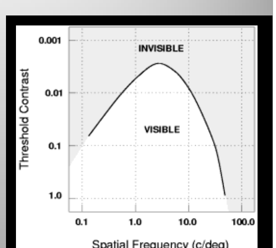




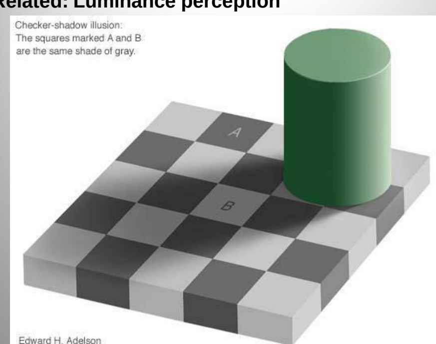
Ernst Mach 1865

5 **We have seen it is indeed a band-pass filter**

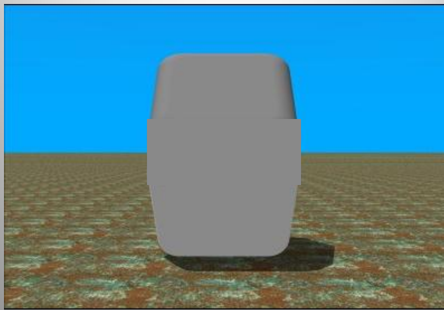




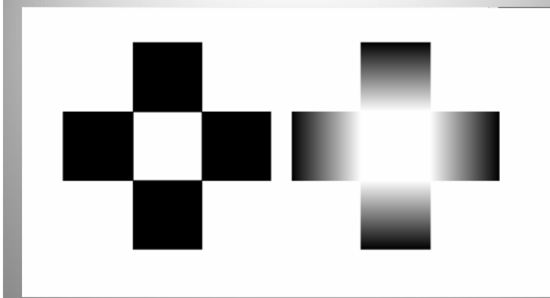
6 **Related: Luminance perception**



7 **Luminance perception: The proof!**



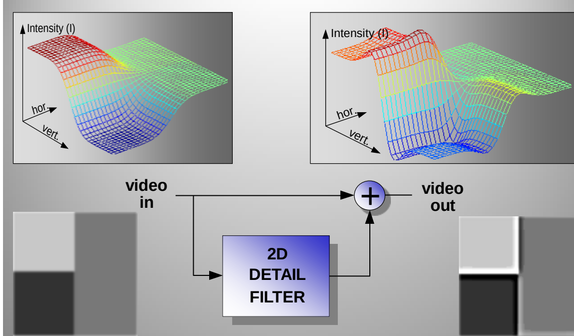
8 **Another example…**



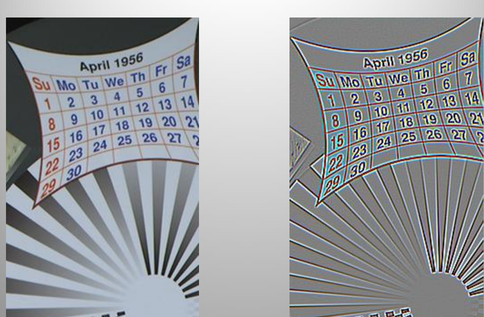
9

Sharpness enhancement: PEAKING

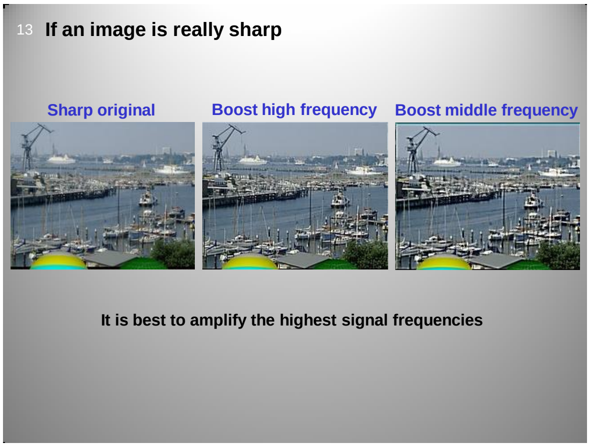
10 **The principle of luminance peaking**

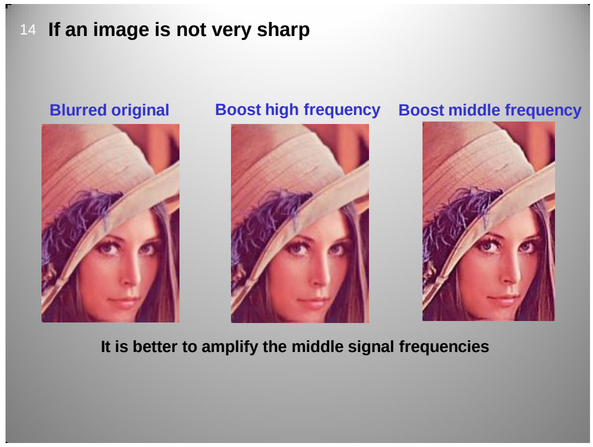


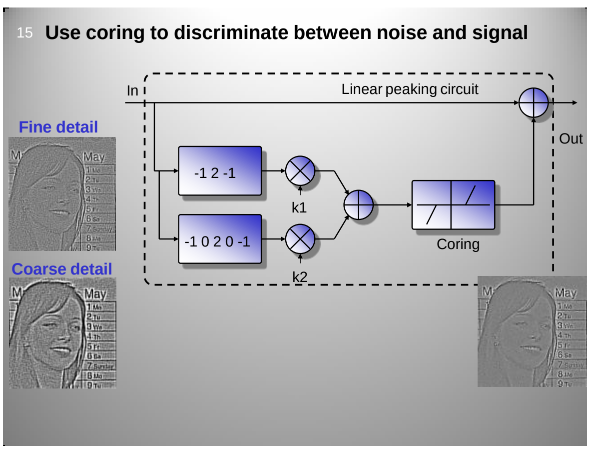
11 **Wheel image 2-D HP filtered**

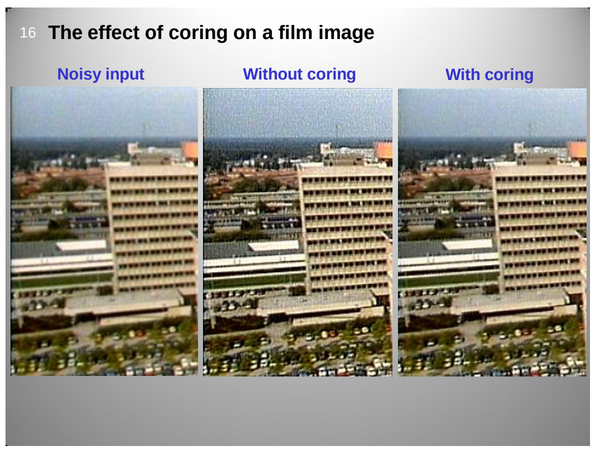


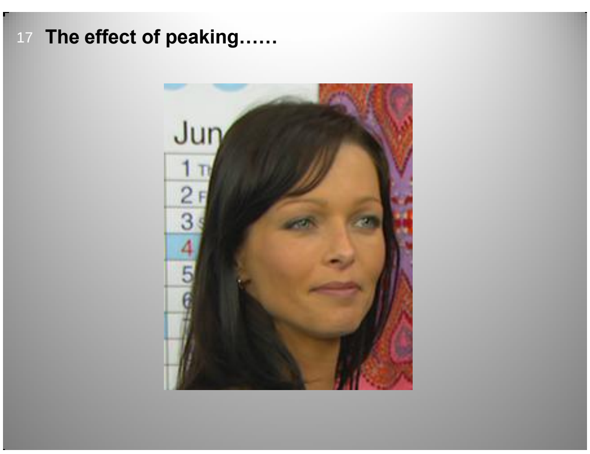
12 **Wheel image with 2-D peaking**

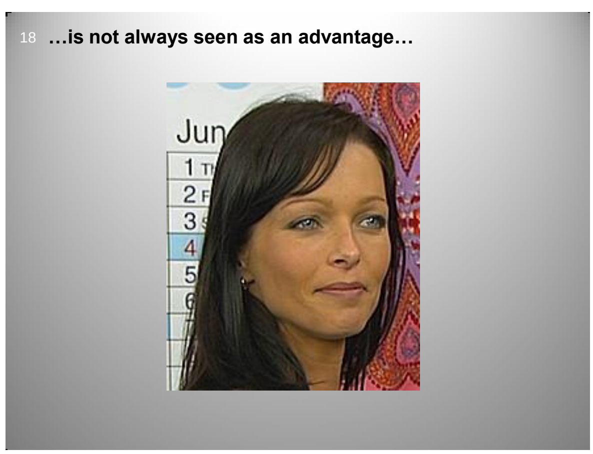

13 If an image is really sharp
Sharp original
Boost high frequency
Boost middle frequency
It is best to amplify the highest signal frequencies

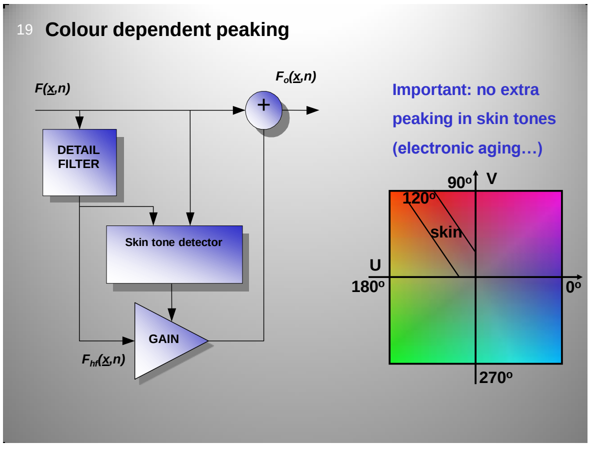

14 If an image is not very sharp
Blurred original
Boost high frequency
Boost middle frequency
It is better to amplify the middle signal frequencies

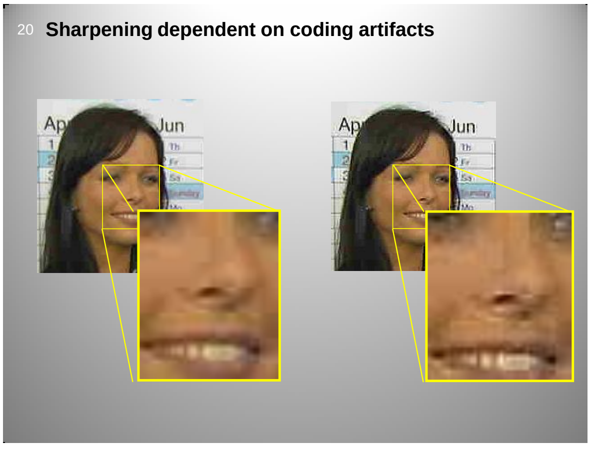

15 Use coring to discriminate between noise and signal
In
Linear peaking circuit
Out
Fine detail
-1 2 -1
k1
-1 0 2 0 -1
k2
Coring
Coarse detail

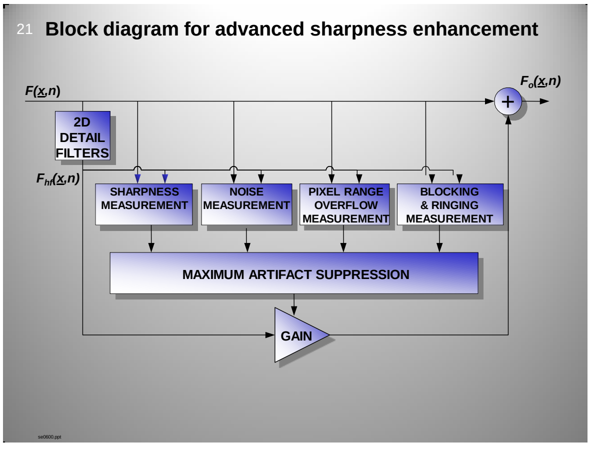

16 The effect of coring on a film image
Noisy input
Without coring
With coring


17 The effect of peaking……


18 …is not always seen as an advantage…

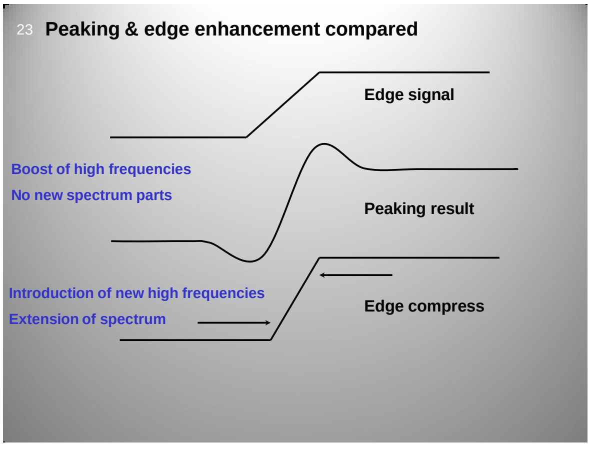


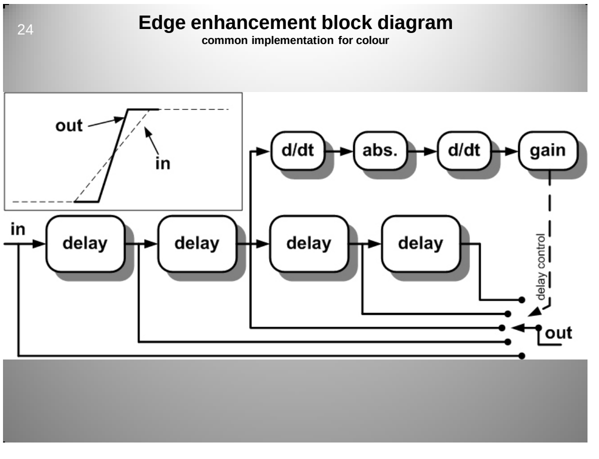


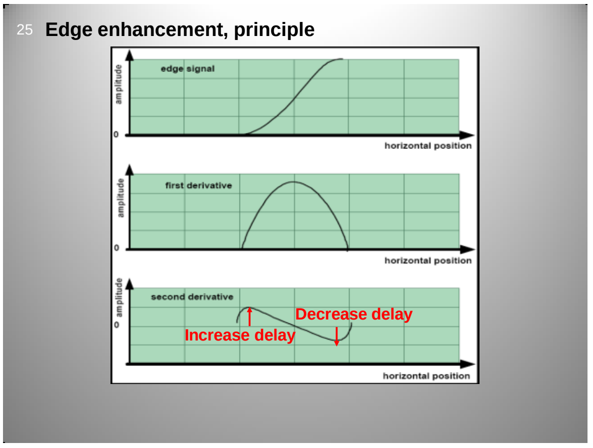


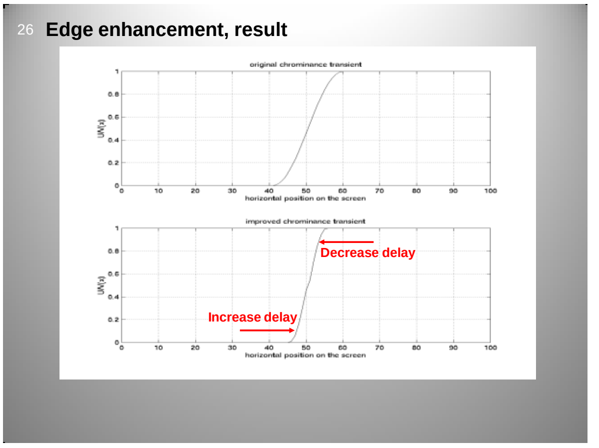
22

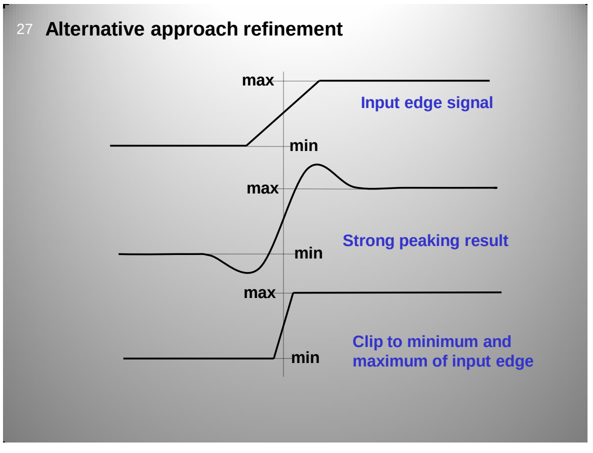
Sharpness enhancement: LTI

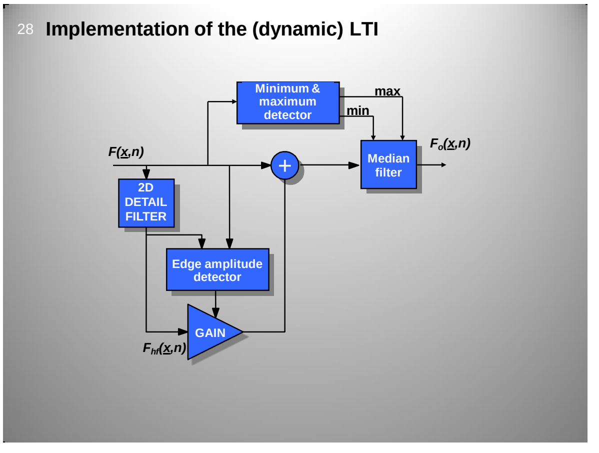


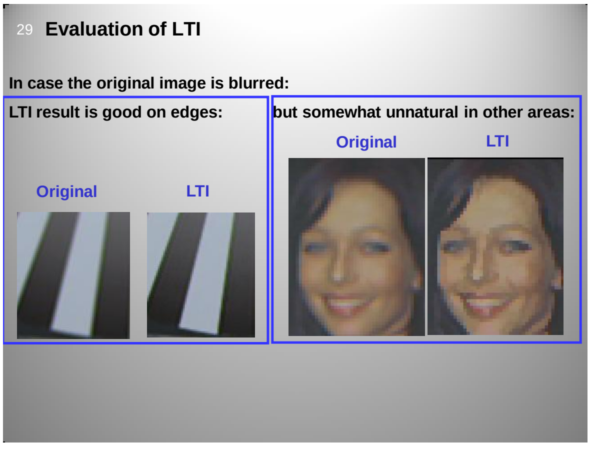


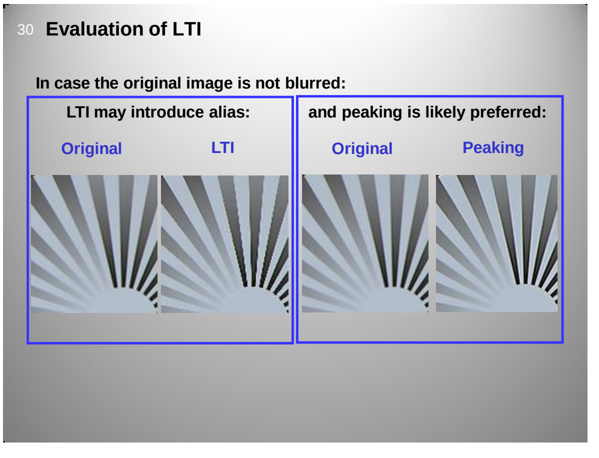

25 Edge enhancement, principle
edge signal
amplitude
horizontal position
first derivative
amplitude
horizontal position
second derivative
amplitude
Decrease delay
Increase delay
horizontal position


26 Edge enhancement, result
original chrominance transient
horizontal position on the screen
improved chrominance transient
Decrease delay
Increase delay
horizontal position on the screen


27 Alternative approach refinement
max
min
Input edge signal
max
min
Strong peaking result
max
min
Clip to minimum and
maximum of input edge


28 Implementation of the (dynamic) LTI
Minimum & maximum detector
max
min
F(x,n)
Median filter
$F_o(x,n)$
2D DETAIL FILTER
Edge amplitude detector
GAIN
$F_{hf}(x,n)$

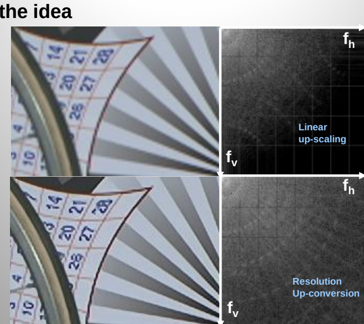

29 Evaluation of LTI
In case the original image is blurred:
LTI result is good on edges:
Original
LTI
but somewhat unnatural in other areas:
Original
LTI


30 Evaluation of LTI
In case the original image is not blurred:
LTI may introduce alias:
Original
LTI
and peaking is likely preferred:
Original
Peaking

31

Resolution up-conversion

34 **This is the idea**

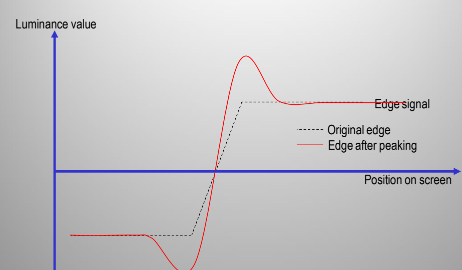


It is not just boosting the details, but really creating new spectral components

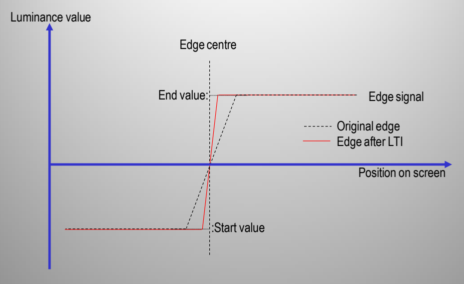
35

Philips: PixelPlus

36 **1st sharpness enhancement technique - peaking**

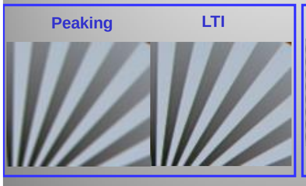


37 2nd sharpness enhancement technique - LTI

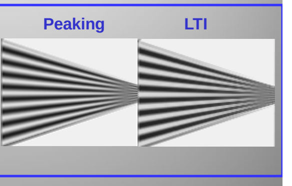


38 There is no single best sharpness enhancement

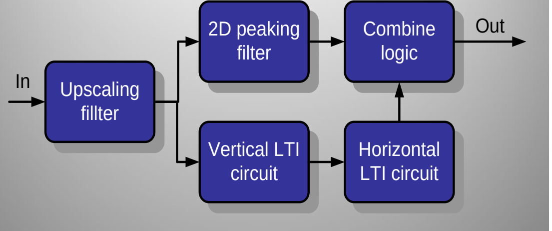
LTI is better on edges:



Peaking is better on texture:



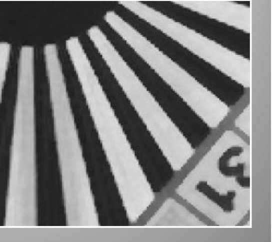
39 Implementation with separable LTI



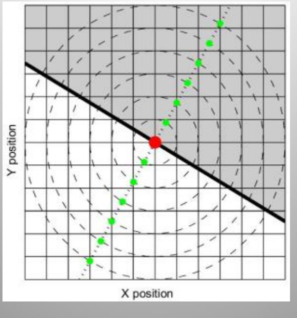
40 Drawback of separable LTI → staircases

Original legacy video

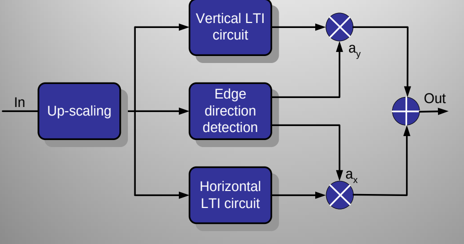
With separable LTI



41 Rotate 1D LTI perpendicular to edge



42 Cost-effective implementation:

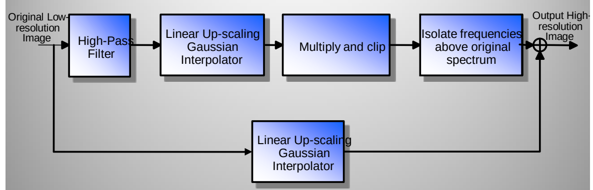


43 Separable and 2D LTI compared

Separable LTI

2D LTI

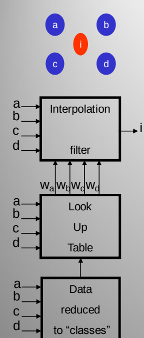
44 Related method (Musashi Institute of Technology, Tokyo)



45

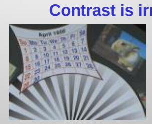
Sony: DRC

46 The unreachable “ideal”



Clue for relevant data reduction:

Contrast is irrelevant for filter:



Normalise local image content and quantize: Adaptive Dynamic Range Coding (Kondo, SONY)

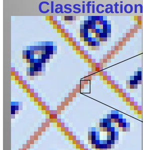
47 Extreme case: 1 bit/pixel to code local structure

$$\mathrm{ADRC}(x) = \begin{cases} 1 & ,(x \geq x_{av}) \\ 0 & ,(x < x_{av}) \end{cases}$$

with

$$x_{av} = \frac{1}{n}\sum_{i=1}^{i=n} x_i$$

Classification code is concatenation of pixels reduced to single bit:



141	186	229
202	229	210
229	220	212

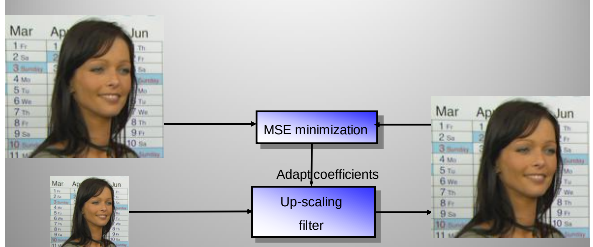
ADRC

Av=206

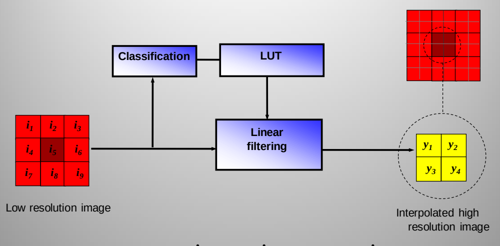
0	0	1
0	1	1
1	1	1

Class code:001011111

48 Per structure class optimize the scaling filter:



49 **Content-adaptive interpolation (DRC, Kondo's method)**

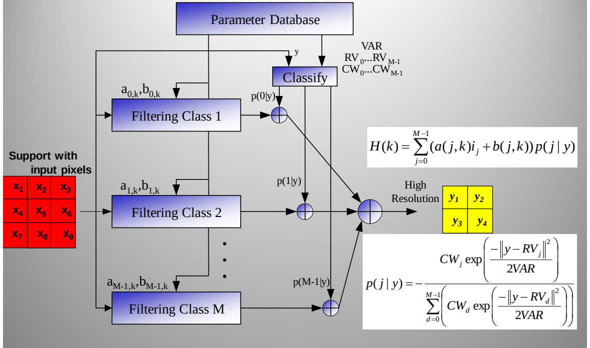


$$y_1 = w_{1,c} i_1 + w_{2,c} i_2 + \cdots + w_{9,c} i_9$$

50

Hewlett Packard: Resolution Synthesis

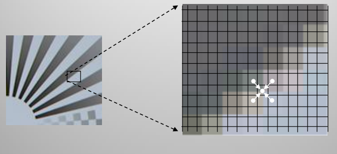
51 **Interpolation Scheme**



52

New Edge-Directed Interpolation (NEDI)

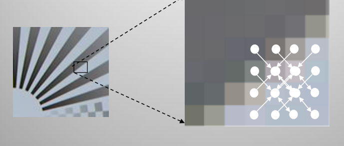
53 **New Edge Directed Interpolation (NEDI)**



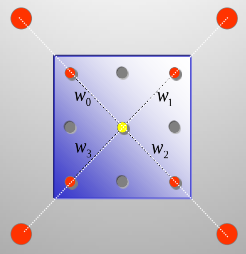
How to find optimal coefficients to interpolate the HD pixel?

54 **Optimal interpolation scale invariant**

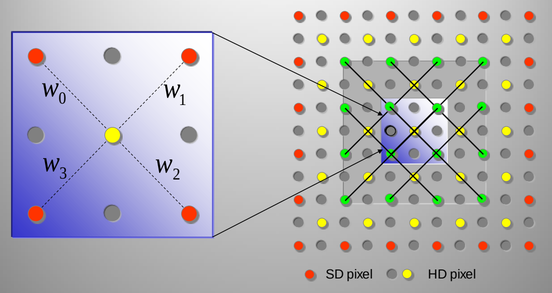
Coefficients are the same as optimal ones on coarser grid!



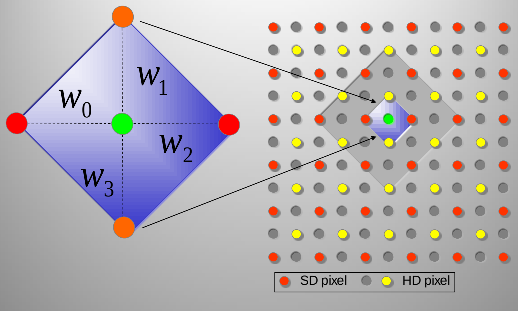
55 **Optimal interpolation scale invariant**



56 **Introduction to NEDI**



57 **NEDI, second step of interpolation**

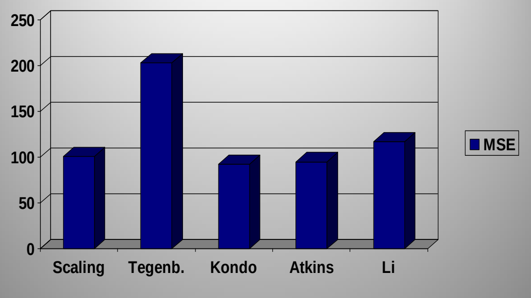


58

Resolution up-conversion

Evaluation

59 **Kondo's method gives the best MSE-score**



60 **What do the images look like?**

Linear scaling

Kondo/Atkins

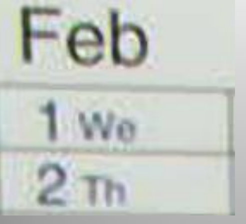
61 **What do the images look like?**

Linear scaling

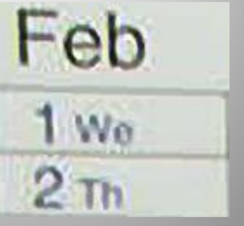
Tegenbosch

62 **What do the images look like?**

Kondo/Atkins

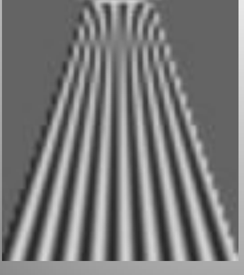


Tegenbosch

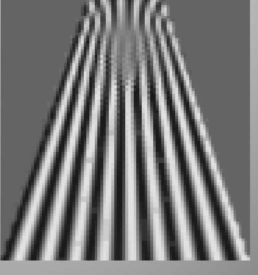


63 **What do the images look like?**

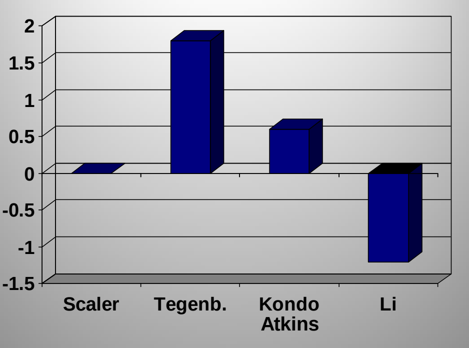
Linear scaling



NEDI



64 **Subjective assessment**

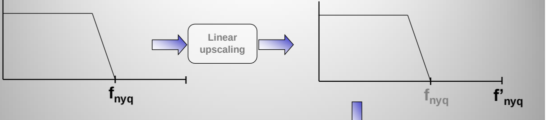


65 **NB: DRC can be trained for de-blurring as well!**

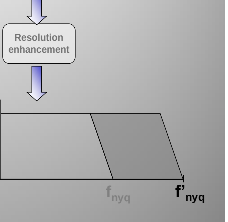
Kondo

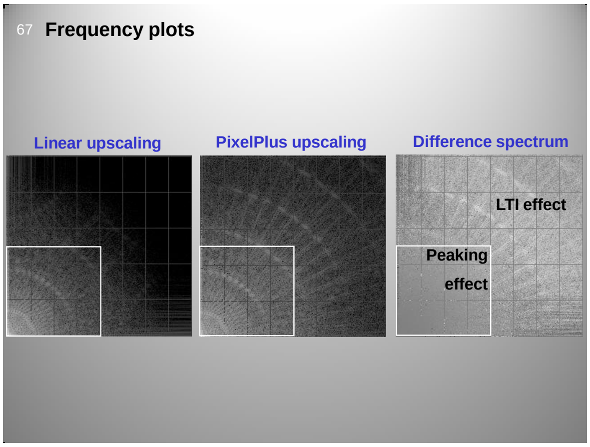
Kondo with de-blurring

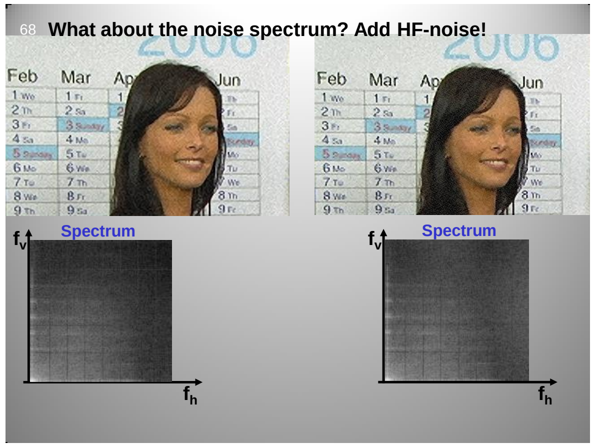
66 **Is the result according to our expectations?**

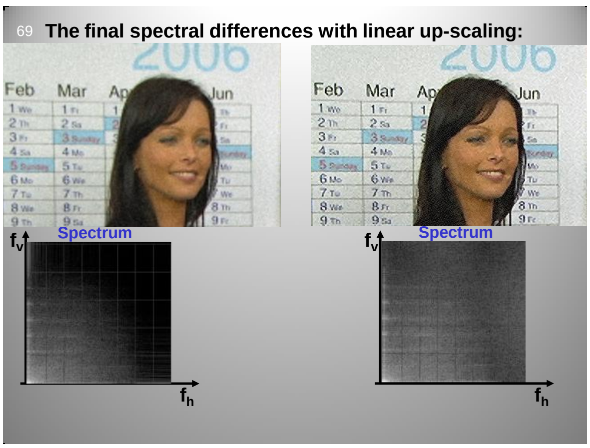


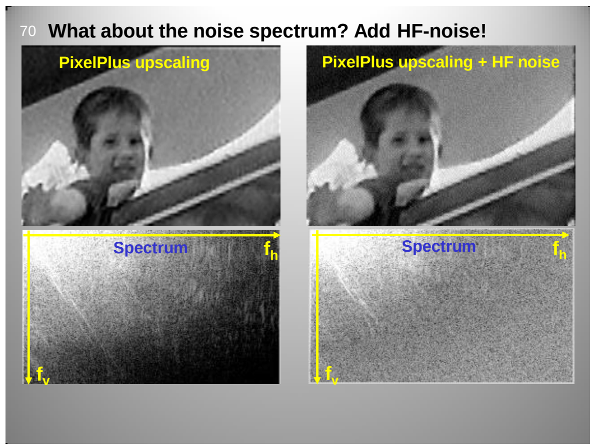
- After linear up-scaling the frequency spectrum remains the same (no new frequencies are added), blurry perception
- With non-linear resolution enhancement new high frequencies are added, sharp perception

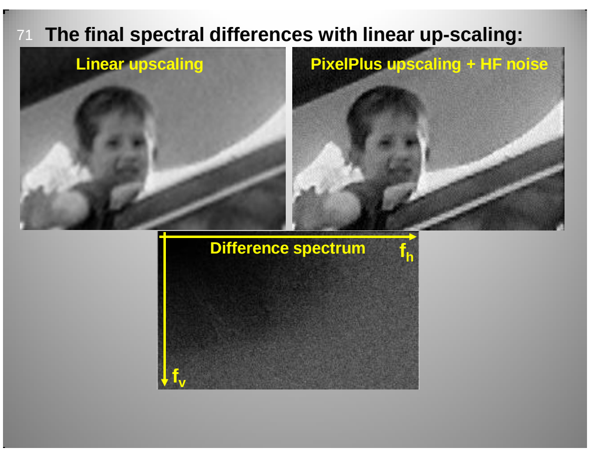












72

Contrast enhancement: black-level

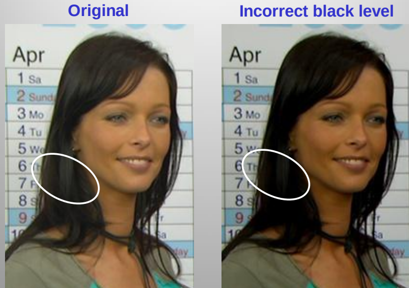
73 **Contrast and subjective sharpness**

74 **An incorrect black level spoils the contrast most**

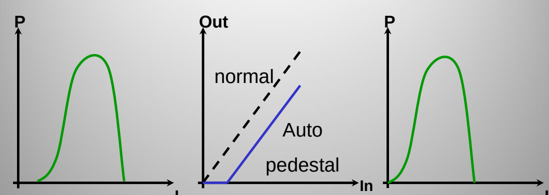
Original   Incorrect black level

75 **Critical not to loose the details in black**

Original   Incorrect black level

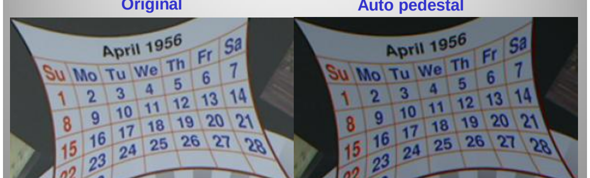


76 **Auto pedestal**



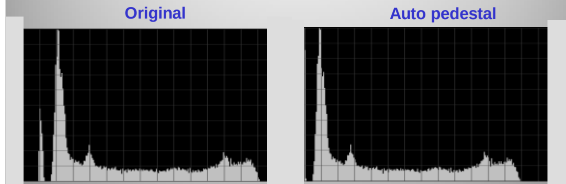
77 **Problem: overall brightness drops**

Original   Auto pedestal

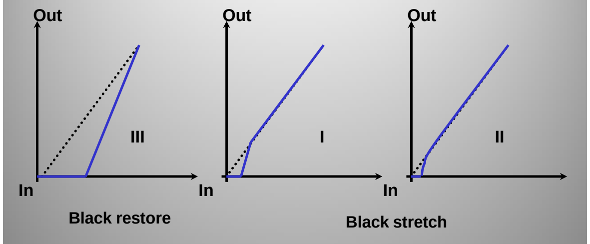


78 **The original and resulting histogram**

Original   Auto pedestal

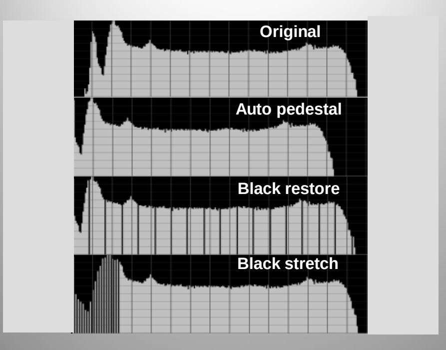


79 **Alternative black processing**



80 **Comparison black restore and black stretch**

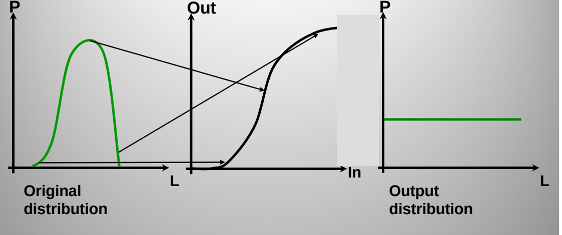
81 **Comparison of resulting histograms**



82

Contrast enhancement: histogram

83 **The essence of histogram equalization**



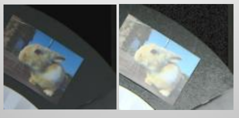
Recipe: we need a steeper transfer near the tops in the histogram…

If the histogram is the gradient of the transfer, the transfer is the <u>integral of the histogram</u>, i.e. the accumulative probability density

84 **Yvonne image histogram equalised**

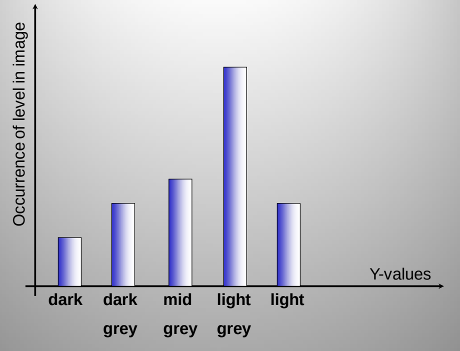
85 **Difference image and video processing**

- For a single image histogram equalization is often already too aggressive:

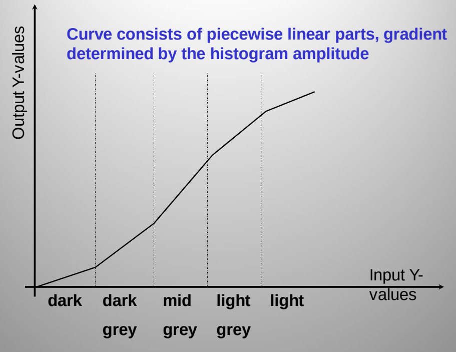


- Moreover for video: temporal consistency
- Therefore, in video we usually talk of histogram modification rather than equalization

86 **Histograms are often calculated with a limited resolution**

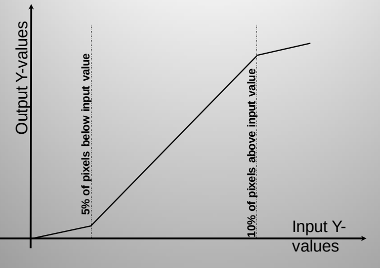


87 **Leading to a simpler transfer curve**

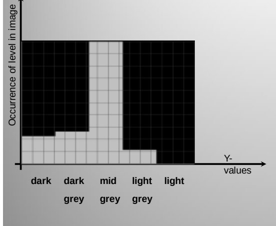


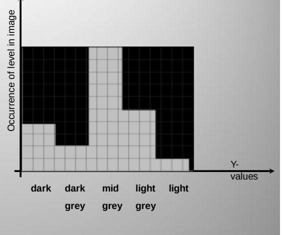
88 **In video often even the curve is further simplified**

Curve consists of 3 linear parts

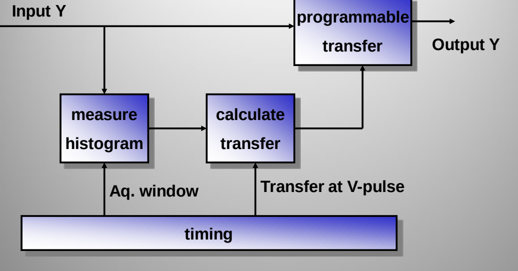


89 **Example result of video (partial) equalization**





90 **Basic block diagram of histogram modification**



91 **Histogram acquisition improvement**

- Problem: uniform acquisition
  - Large flat areas (background) dominate in histogram and tend to get stretched too much
- Improvement
  - Fill histogram bins only with data that differs significantly from earlier sample (skip pixels until difference with last sample above threshold)
  - Detailed areas now become dominant and profit from contrast improvement

92 **Problem of background enhancement**

•Try to acquire the histogram information from the foreground

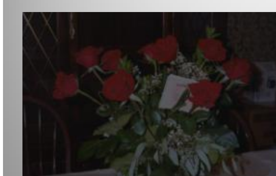
•Measurements only directly near edges

93 **Histogram modification of colour images**

- Gray scale transforms and histogram modification techniques can be applied by treating a color image as three gray images
  - However, independent processing of the colours leads to colour shifts


- The relative colour can be retained by applying the gray scale modification technique to one of the colour channels, and then using the ratios from the original image to find the other colour channel values

94 **Histogram equalization of color images**



a) Original poor contrast image

b) Histogram equalization based on the red color band

95 **Histogram equalization of color images**

c) Histogram equalization based on the green color band

d) Histogram equalization based on the blue color band

Note: In this case the red band gives the best results
This will depend on the image and the desired result