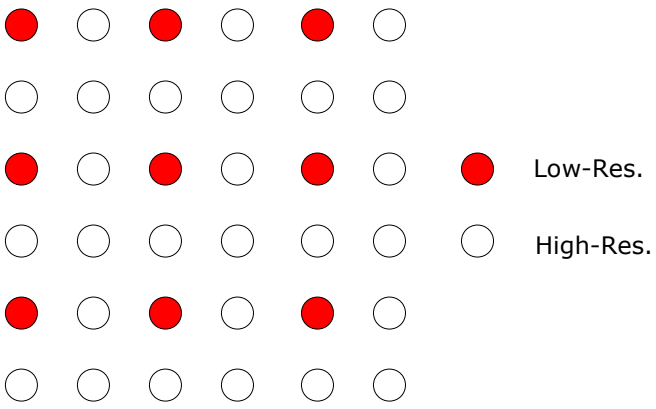
Interpolazione.

Click to add name
data/time

2007
1987
20 years dedicated to the future

Scenario I: Resolution Enhancement



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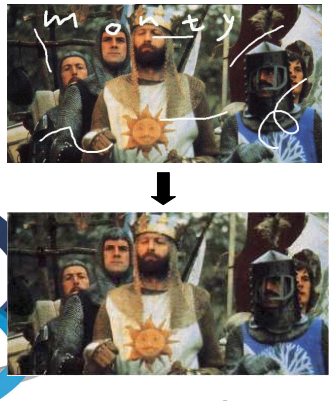
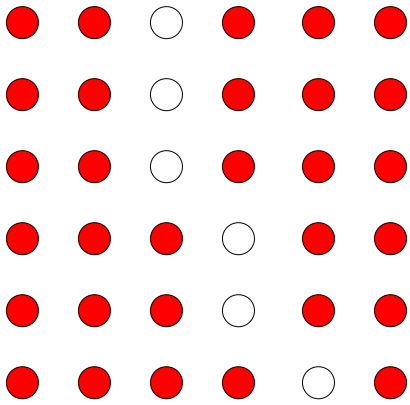
Scenario II: Image Inpainting





Non-damaged Damaged

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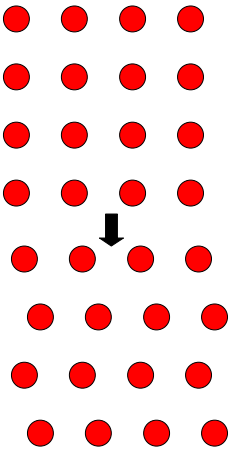
Scenario III: Image Warping



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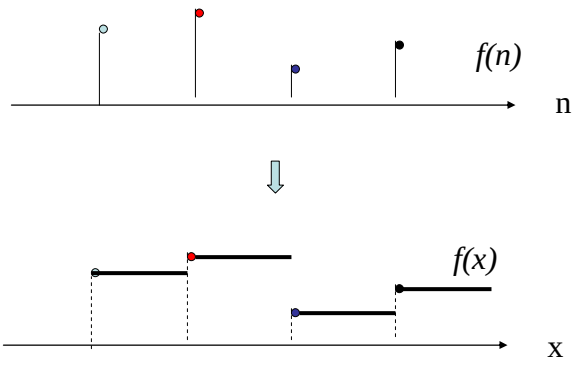
1D Zero-order (Replication)



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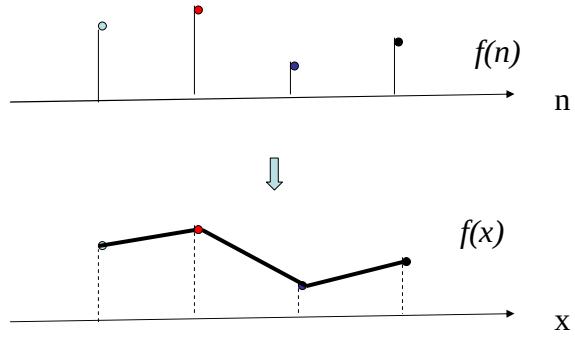
1D First-order Interpolation (Linear)



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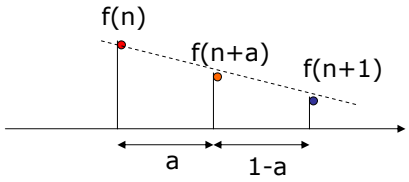
Linear Interpolation Formula

Basic idea: the closer to a pixel, the higher weight is assigned



$$f(n+a)=(1-a)\times f(n)+a\times f(n+1),\ 0<a<1$$

Note: when a=0.5, we simply have the average of two

Numerical Examples

f(n)=[0,120,180,120,0]

↓ Interpolate at 1/2-pixel

f(x)=[0,60,120,150,180,150,120,60,0], x=n/2

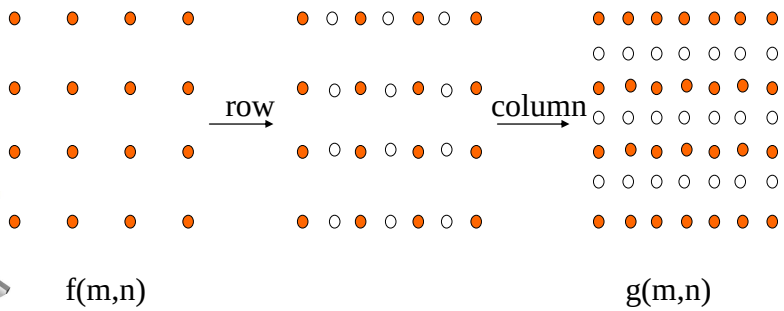
↓ Interpolate at 1/3-pixel

f(x)=[0,20,40,60,80,100,120,130,140,150,160,170,180,…], x=n/6

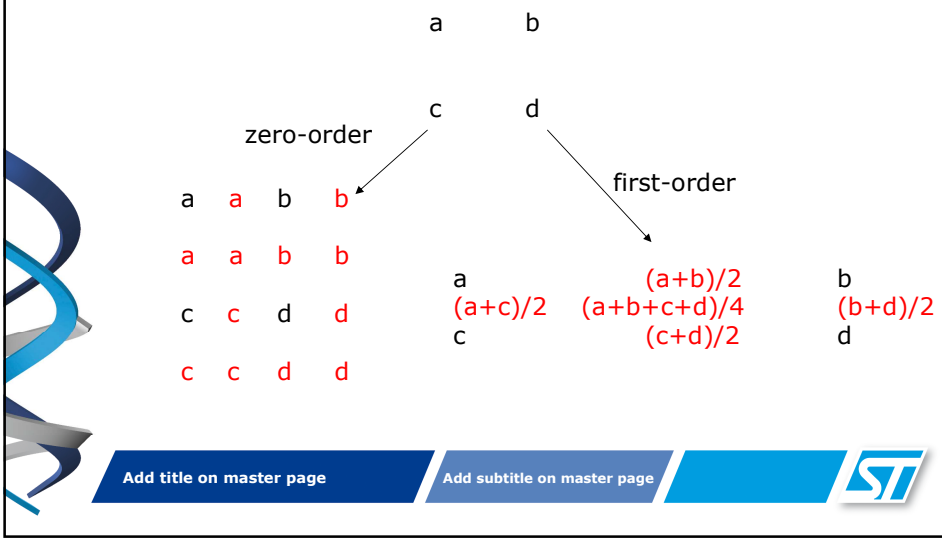
From 1D to 2D

- Just like separable 2D transform (filtering) that can be implemented by two sequential 1D transforms (filters) along row and column direction respectively, 2D interpolation can be decomposed into two sequential 1D interpolations.
- The ordering does not matter
  - (row-column = column-row)

Graphical Interpretation of Interpolation at Half-pel



Numerical Examples



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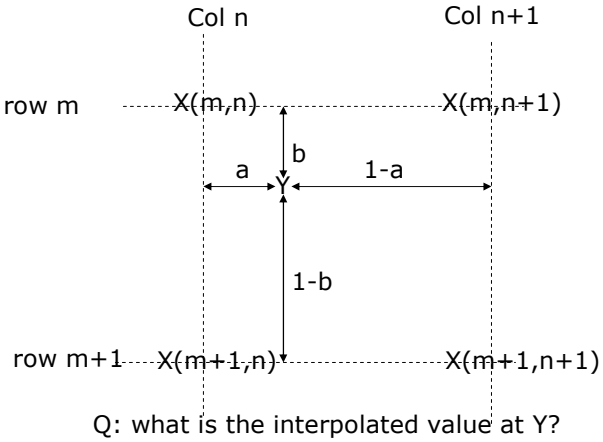
Numerical Examples (Con't)



Q: what is the interpolated value at Y?
Ans.: (1-a)(1-b)X(m,n)+(1-a)bX(m+1,n)
+a(1-b)X(m,n+1)+abX(m+1,n+1)

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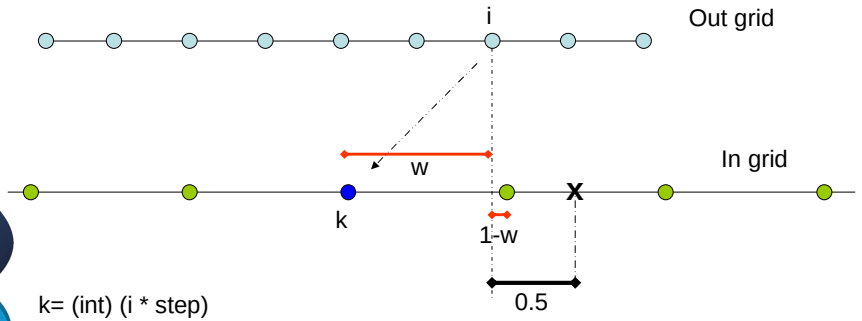
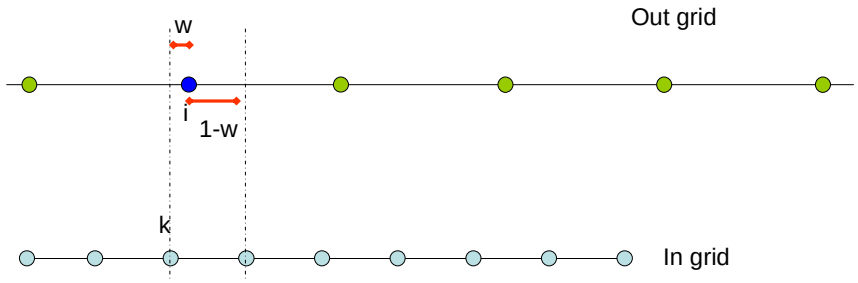
upsampling



k= (int) (i * step)
w = (i * step) – k

Where:
step=(in - 1) / (out - 1)

downsampling



k= (int) (i * step)
w = (i * step) – k

Where:
step=(in - 1) / (out - 1)

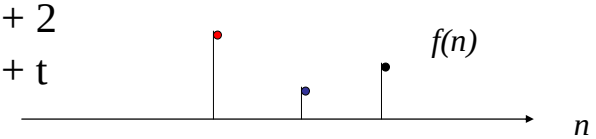
1D Third-order Interpolation (Cubic)

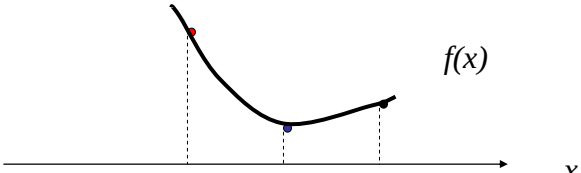
P0(t) $2t^2 - t^3 - t$

P1(t) $3t^3 - 5t^2 + 2$

P2(t) $4t^2 - 3t^3 + t$

P3(t) $t^3 - t^2$





Cubic spline fitting

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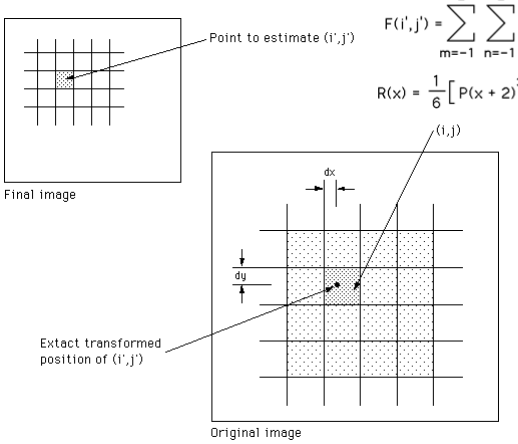
Bicubic Interpolation*



$$F(i',j') = \sum_{m=-1}^{2} \sum_{n=-1}^{2} F(i+m, j+n)\, R(m-dx)\, R(dy-n)$$

$$R(x) = \frac{1}{6}\left[P(x+2)^3 - 4\,P(x+1)^3 + 6\,P(x)^3 - 4\,P(x-1)^3 \right]$$

$$P(x) = \begin{cases} x & x > 0 \\ 0 & x \le 0 \end{cases}$$

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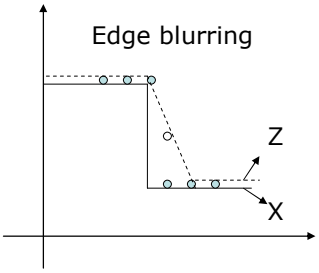
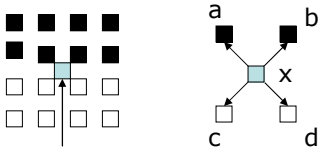
Limitation with bilinear/bicubic

- Edge blurring
- Jagged artifacts



Directional Interpolation*

Step 1: interpolate the missing pixels along the diagonal

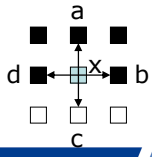


black or white?

Since |a-c|=|b-d|

x has equal probability of being black or white

Step 2: interpolate the other half missing pixels



Since |a-c|>|b-d|

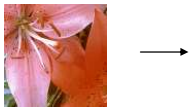
x=(b+d)/2=black

Pixel Replication

low-resolution
image (100×100)

high-resolution
image (400×400)

Bilinear Interpolation



low-resolution
image (100×100)

high-resolution
image (400×400)

Bicubic Interpolation

low-resolution
image (100×100)

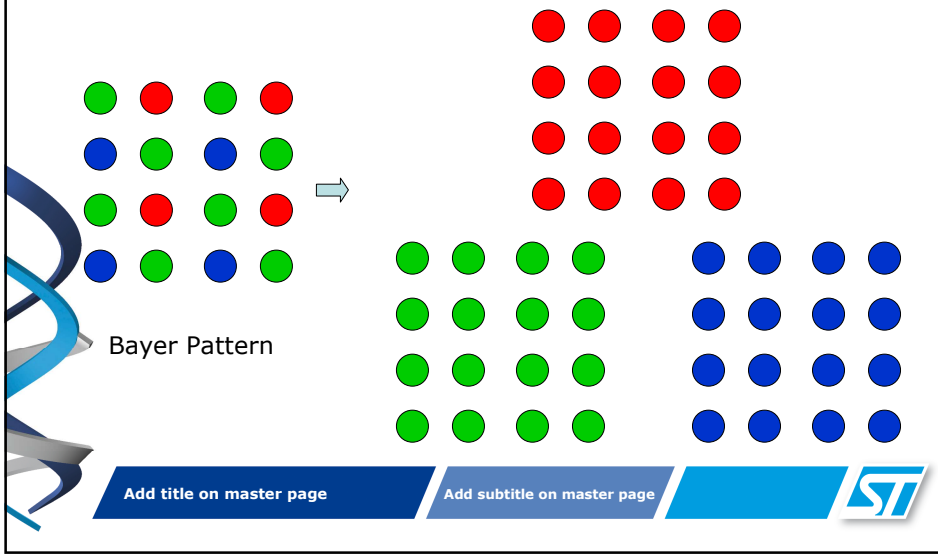
high-resolution
image (400×400)

Edge-Directed Interpolation (Li&Orchard'2000)

low-resolution
image (100×100)

high-resolution
image (400×400)

Image Demosaicing
(Color-Filter-Array Interpolation)



Bayer Pattern