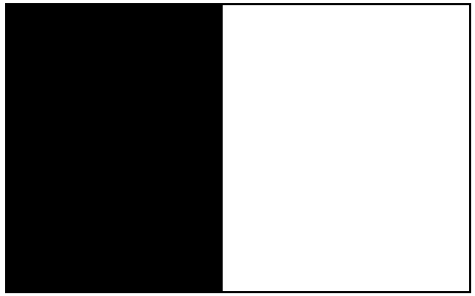
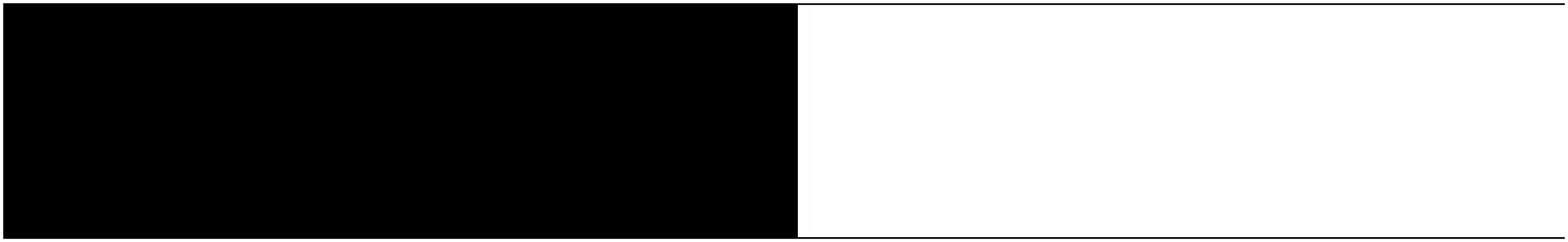
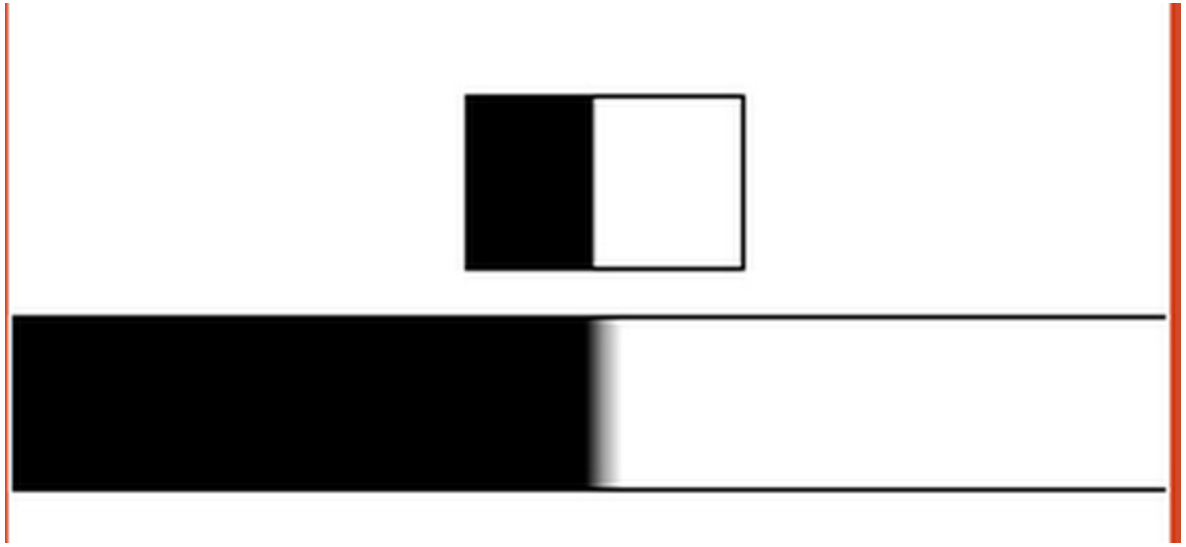
The SUPER_RESOLUTION

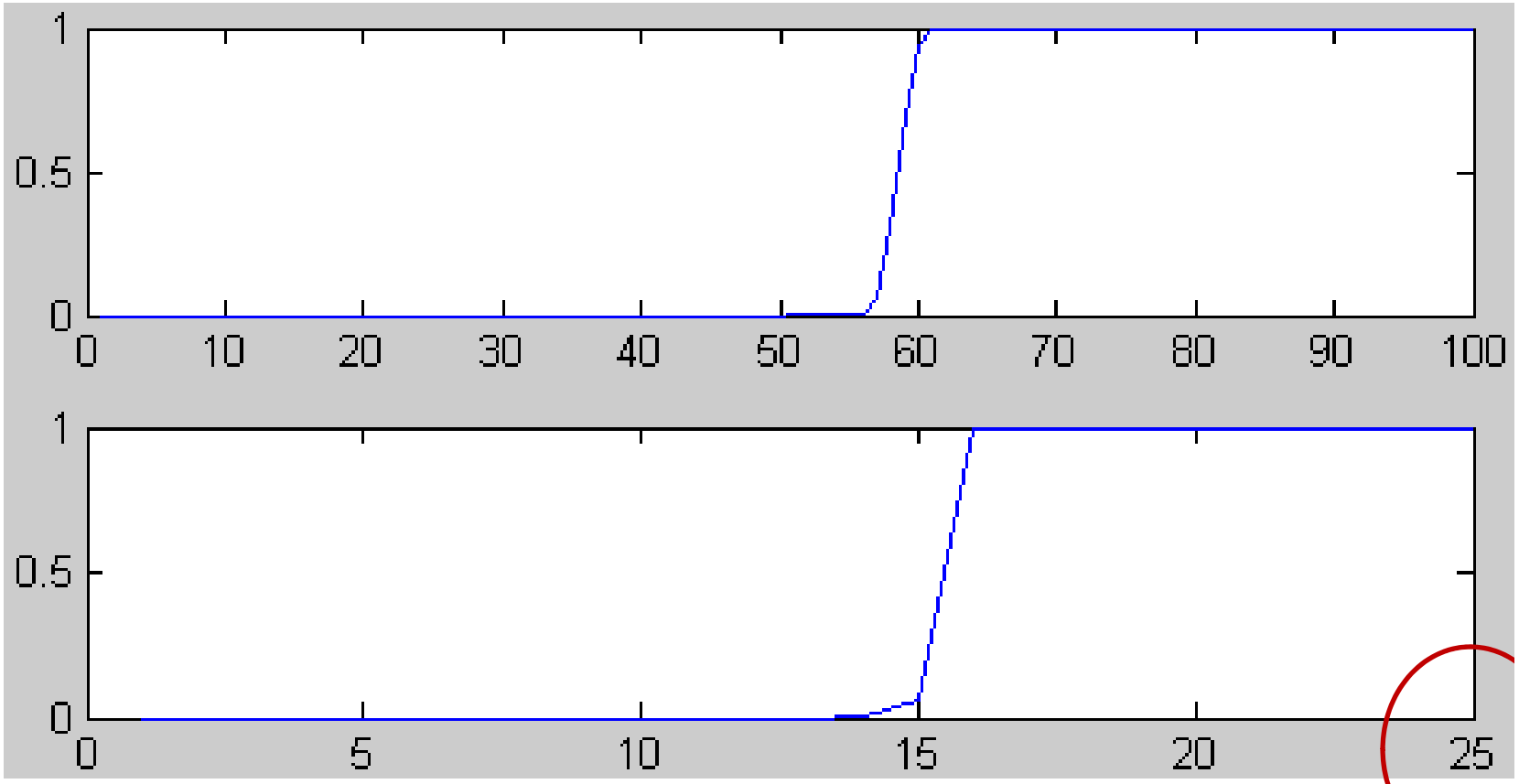
EDGE RECONSTRUCTION

+ Restoration



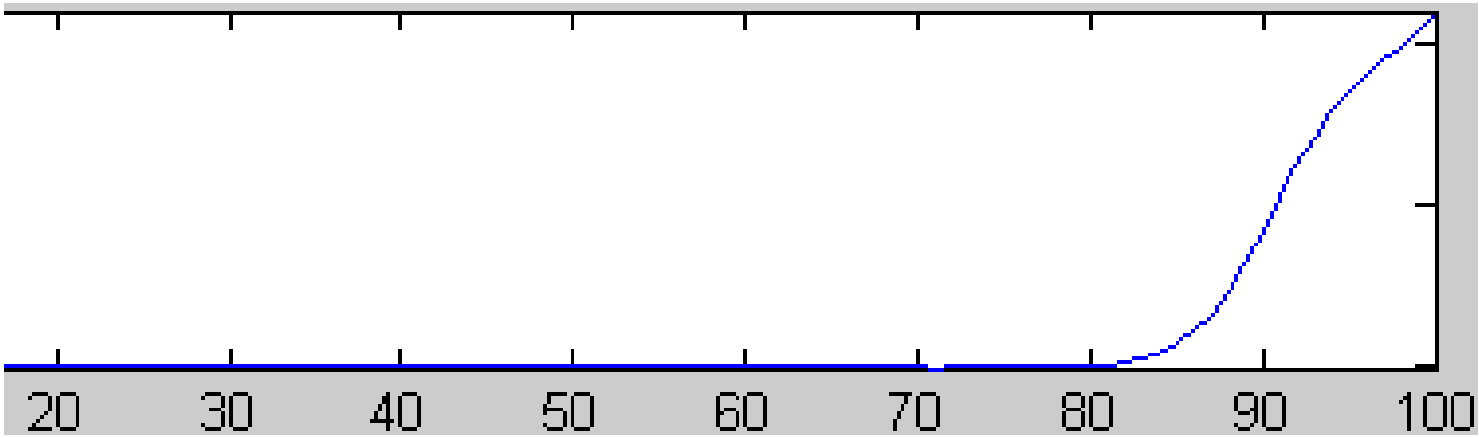




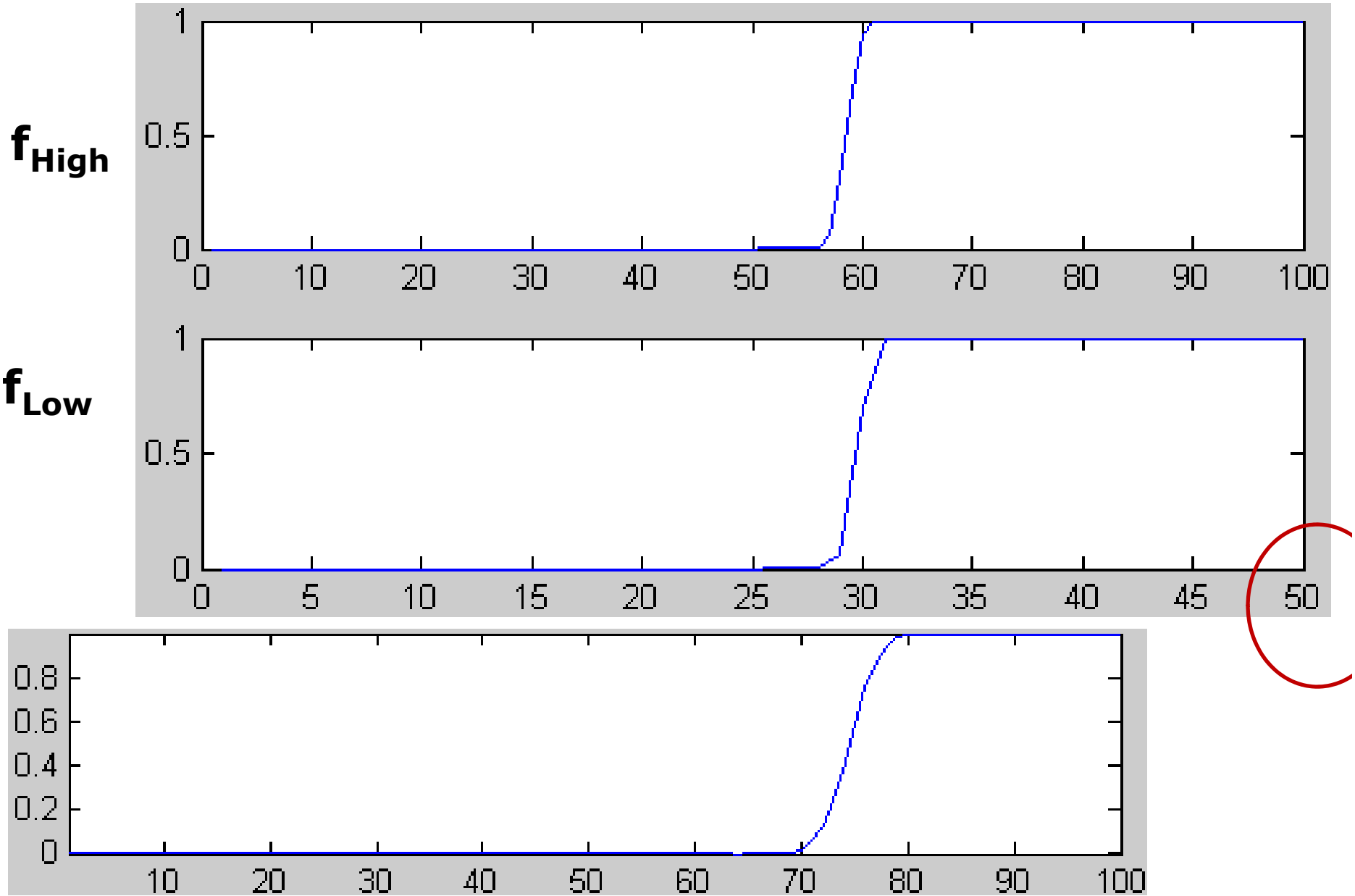


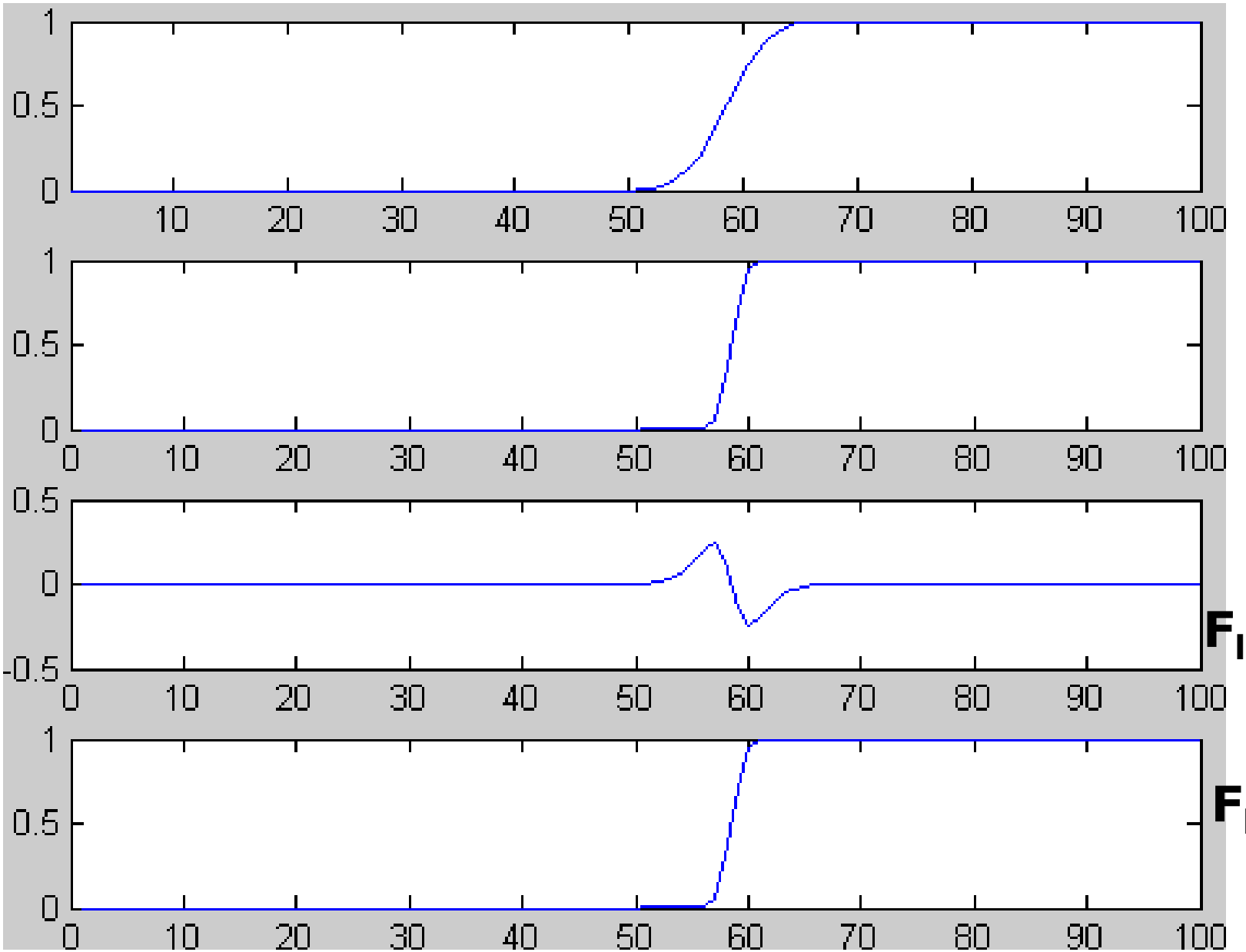
f_{High}

f_{Low}



Upsampled (by 4) F_{low}


f_{High}
f_{Low}
Upsampled (by 2) F_{low}

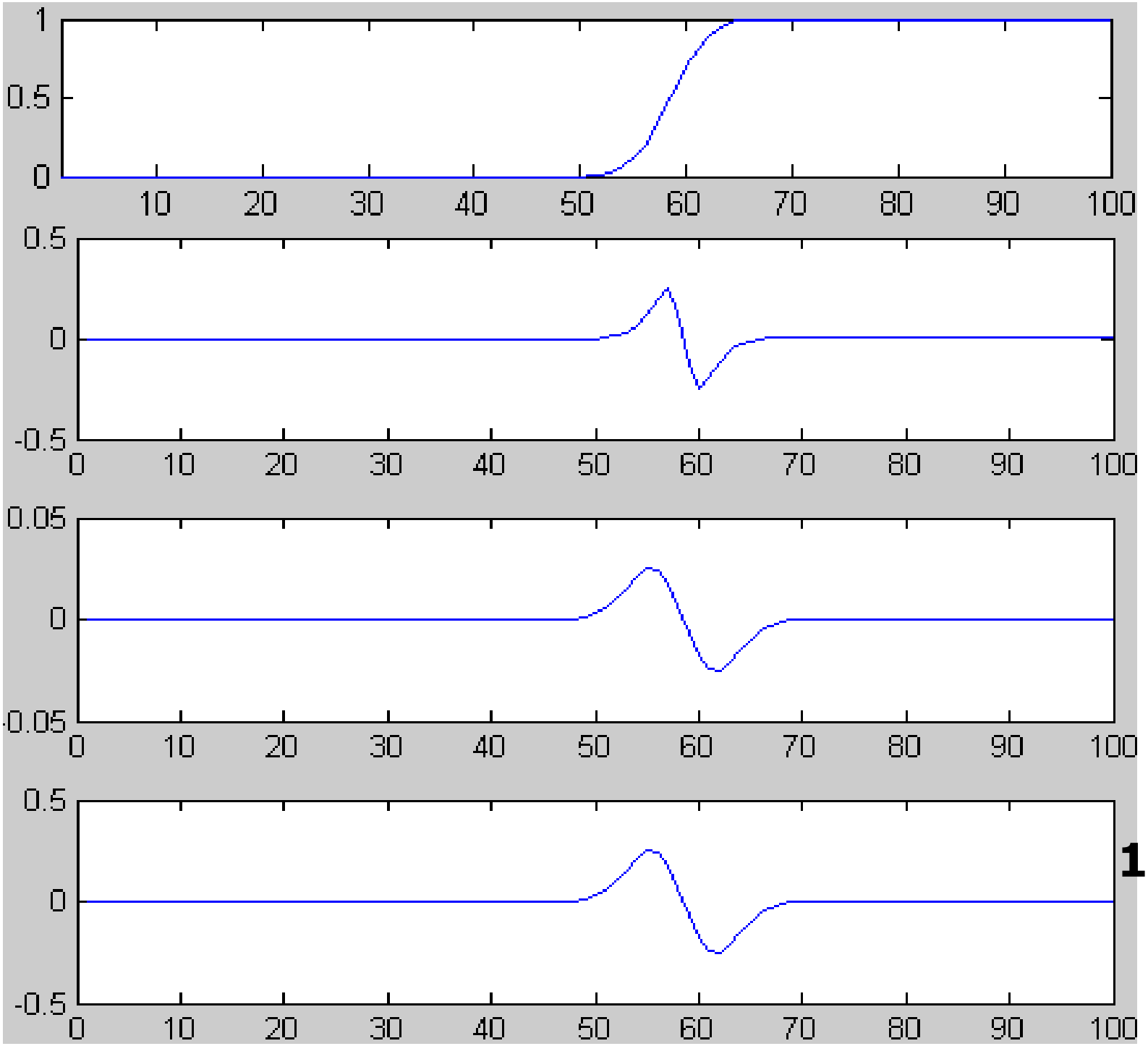


f_{Low}

f_{High}

$Ds = F_{low} - f_{High}$

$F_{low} - DS$

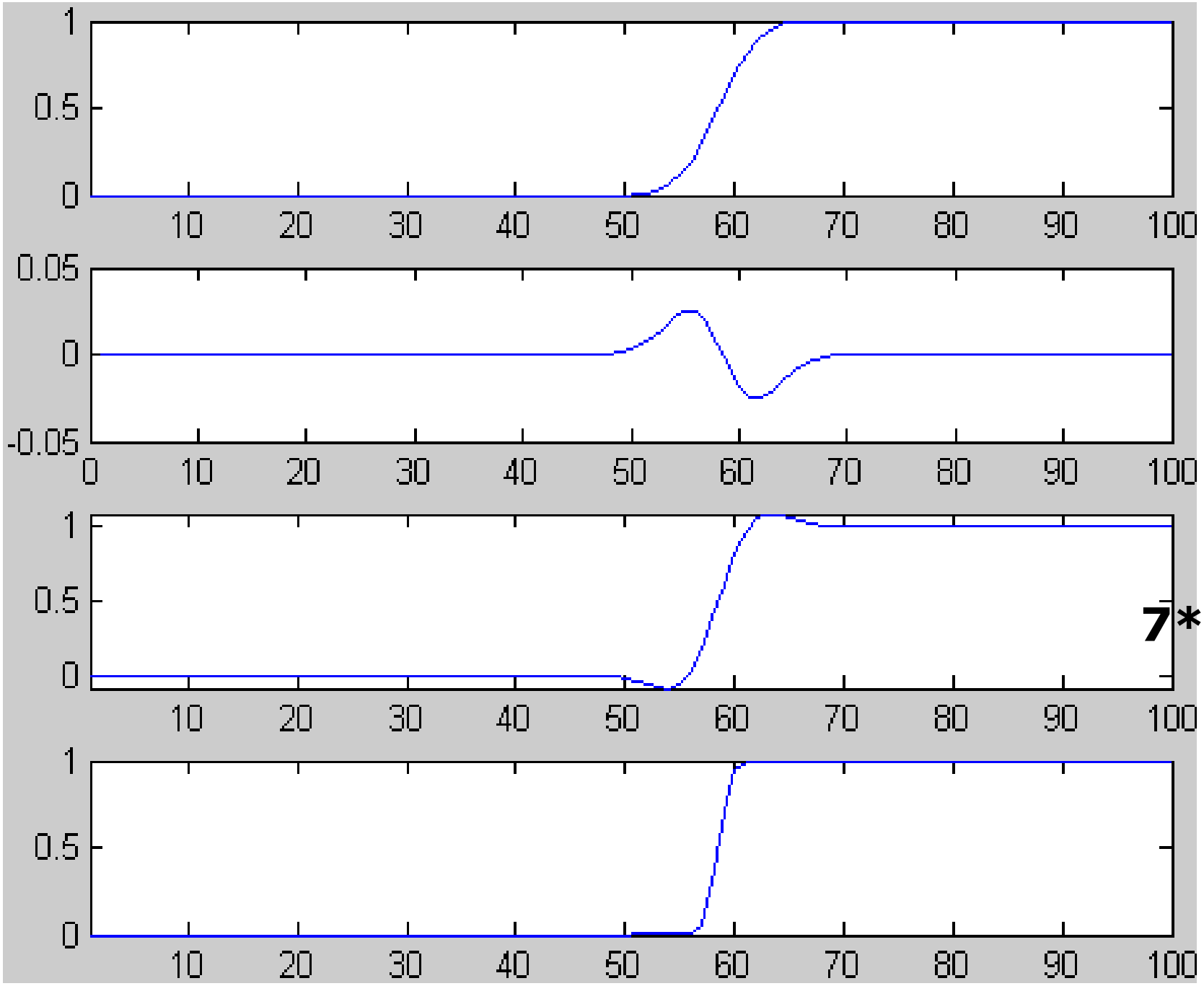


f_{Low}

Ds

$\nabla^2 f_{Low}$

$10*\nabla^2 f_{Low}$


1
0.5
0
10 20 30 40 50 60 70 80 90 100
f_{Low}
0.05
0
-0.05
0 10 20 30 40 50 60 70 80 90 100
$\nabla^2 f_{Low}$
1
0.5
0
10 20 30 40 50 60 70 80 90 100
$F_{low} - 7*\nabla^2 f_{Low}$
1
0.5
0
10 20 30 40 50 60 70 80 90 100
f_{High}

$$f_H = f_L - k * \nabla^2 f_L;$$

- Need to learn an optimal K, for a class of edges;

- Use del2(fL) as initial guess and formulate a signal re-shaping (anti-blur) or optimization,

or
work in transform domain ??

Relates Enhancement of images →

Sharpening revisited

- What does blurring take away?

Let's add it back:

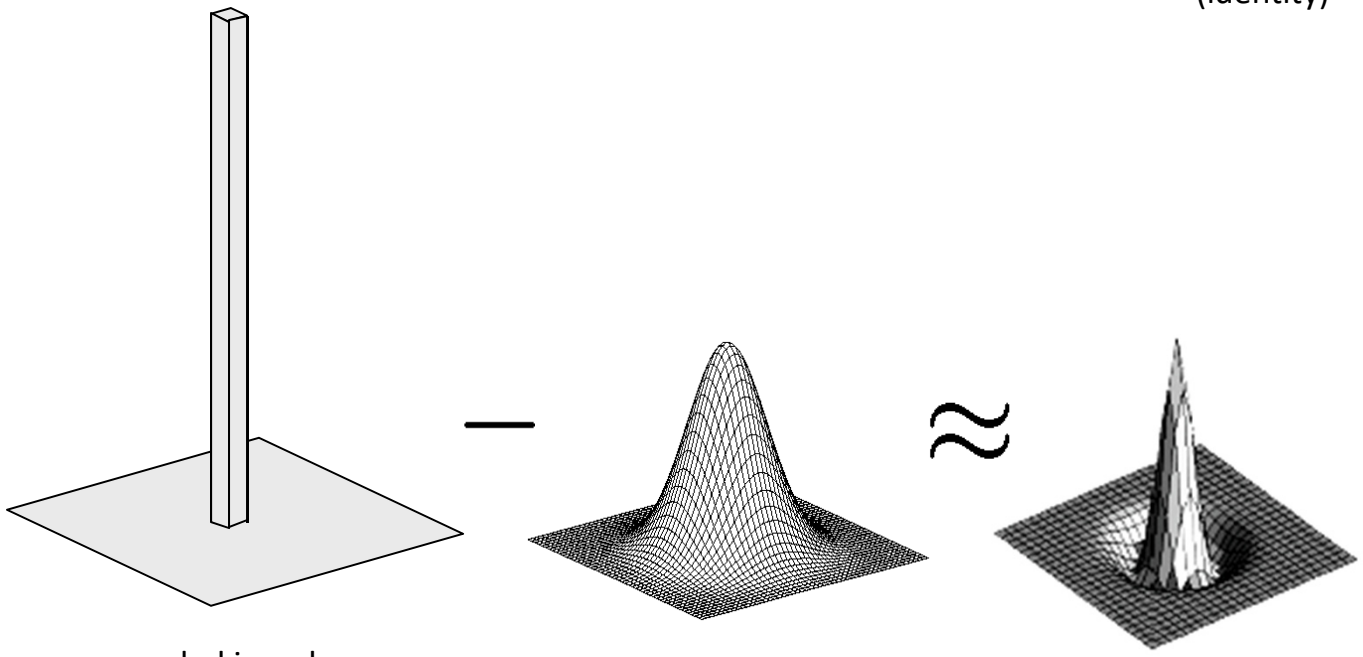
Source: S. Lazebnik

Sharpen filter

$$F + \alpha\,(F - \underbrace{F * H}_{\text{blurred image}})$$

image

unit impulse (identity)



scaled impulse

Gaussian

Laplacian of Gaussian

Sharpen filter

Unsharp Masking and Highboost Filtering Image enhancement can also be obtained using smoothing spatial filters, instead of the Laplacian. Assume that f is the input image (that may be blurry). We first compute a smoother image f_{smooth} by applying a smoothing linear filter to f as discussed before. Then the sharper output image g is defined by

$$g(x,y) = f(x,y) + k \cdot \Big(f(x,y) - f_{smooth}(x,y)\Big), \tag{6}$$

where $k \geq 0$ is a coefficient. When $k = 1$ the method is called unsharp masking. When $k > 1$, it is called highboost filtering, since the edges and details are even more highlighted.

Consider the case $k = 1$ in equation (6). When we compute $f - f_{smooth}$, this gives negative values on the left of the edge, and positive values on the right of the edge, and values close to 0 elsewhere. Thus when we compute $f + (f - f_{smooth})$ this provides the sharper corrected edge in g.

Consider first the denoising problem for simplicity. Let g be the given noisy image, f the image to be restored, linked through the relation $g(x,y) = f(x,y) + n(x,y)$.

Let's recall for a moment the enhancement method using the Laplacian: $g = f - \triangle f$, where f was the input blurry image and g was the sharper output image. However, to remove noise, we need the opposite process of smoothing. So let's invert the relation $g = f - \triangle f$ to obtain

$$f = g + \triangle f, \tag{11}$$

where g is the input noisy image and f is the denoised processed image. This is a linear partial differential equation, with unknown f. There are many ways to solve (11).

QUESTIONS AND DISCUSSIONS .....