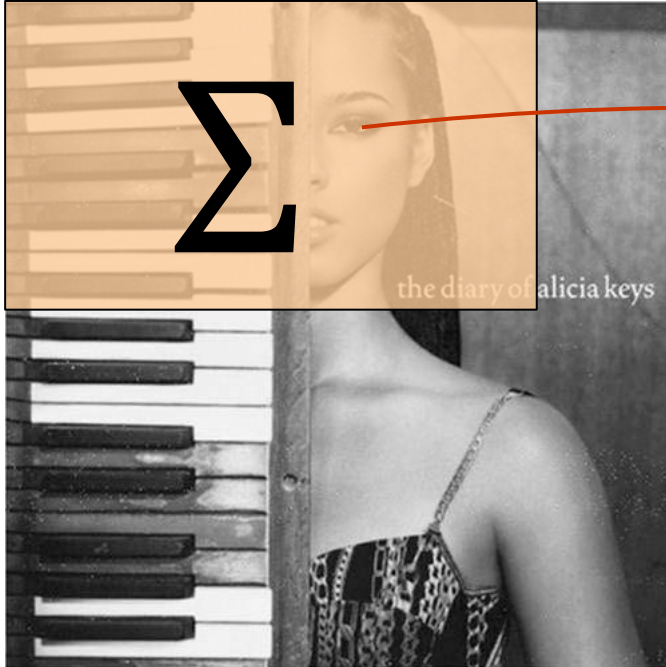
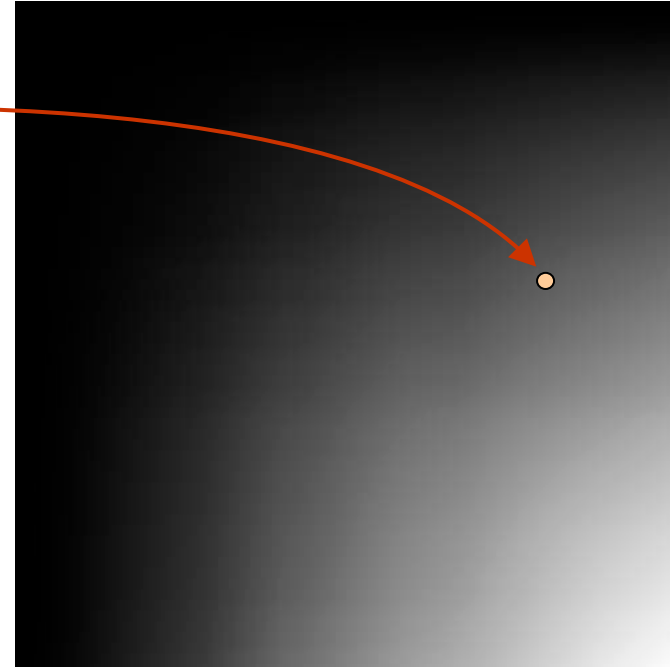


# Integral image



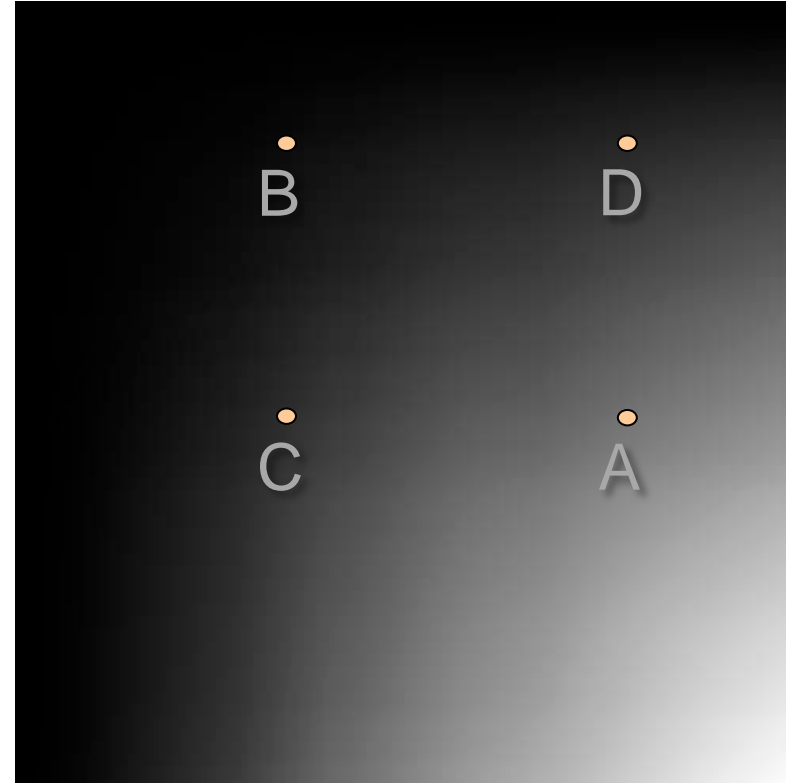
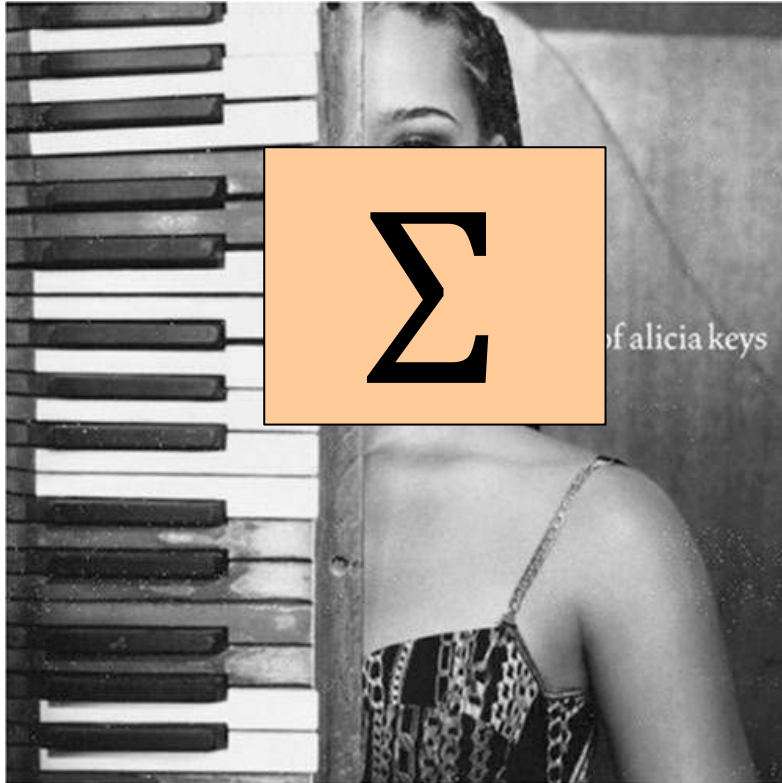
$$f[x, y]$$



$$i[x, y] = \sum_{u=0}^x \sum_{v=0}^y f[u, v]$$

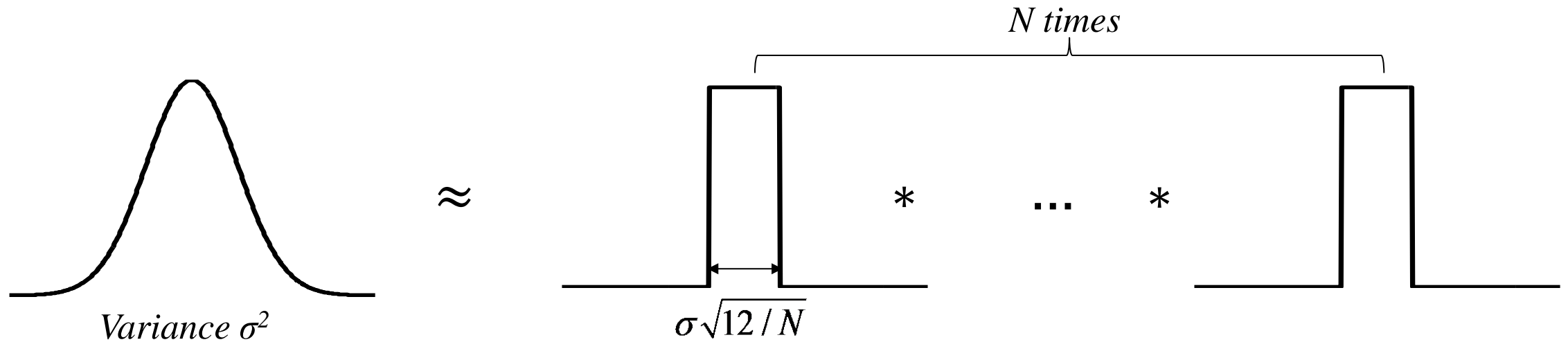
$$j[x, y] = j[x, y-1] + f[x, y]$$
$$i[x, y] = i[x-1, y] + j[x, y]$$

# Box filtering with integral image



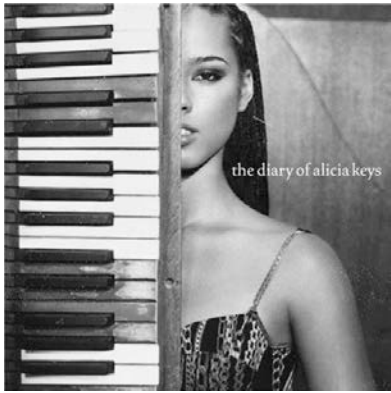
$$\text{Sum} = A + B - C - D$$

# Gaussian filtering by repeated box filtering

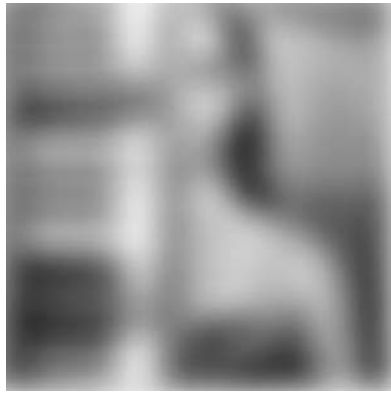


- Approximate convolution with Gaussian kernel by convolution with box kernel, repeated N times
- Convolution with box kernel can be computed efficiently using integral image

# Gaussian filtering by repeated box filtering



Original image  
500x500



Gaussian filtered  
 $\sigma = 20$ , 81x81 kernel

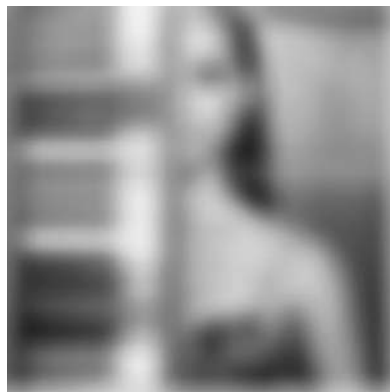
Direct implementation:  
6561 multiplications and  
6560 additions per pixel

x-y separable filtering:  
162 multiplications and  
160 additions per pixel

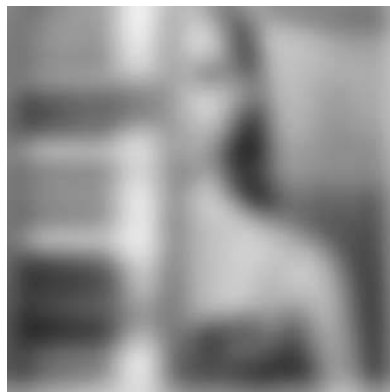
20 additions or subtractions per pixel



Box filtered  
after N = 1



Box filtered  
after N = 2



Box filtered  
after N = 3



Box filtered  
after N = 4

