SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECE351 – IMAGE PROCESSING AND COMPUTER VISION

III B.E. ECE / V SEMESTER

UNIT 5 – COMPUTER VISION

TOPIC – Pyramids

Pyramids

- Downsampling (decimation)
- Upsampling (interpolation)
- Pyramids
  - Gaussan Pyramids
  - Laplacian Pyramids
- Applications
  - Template matching (object detection)
  - Detecting stable points of interest
  - Image Registration
  - Compression
  - Image Blending
  - …

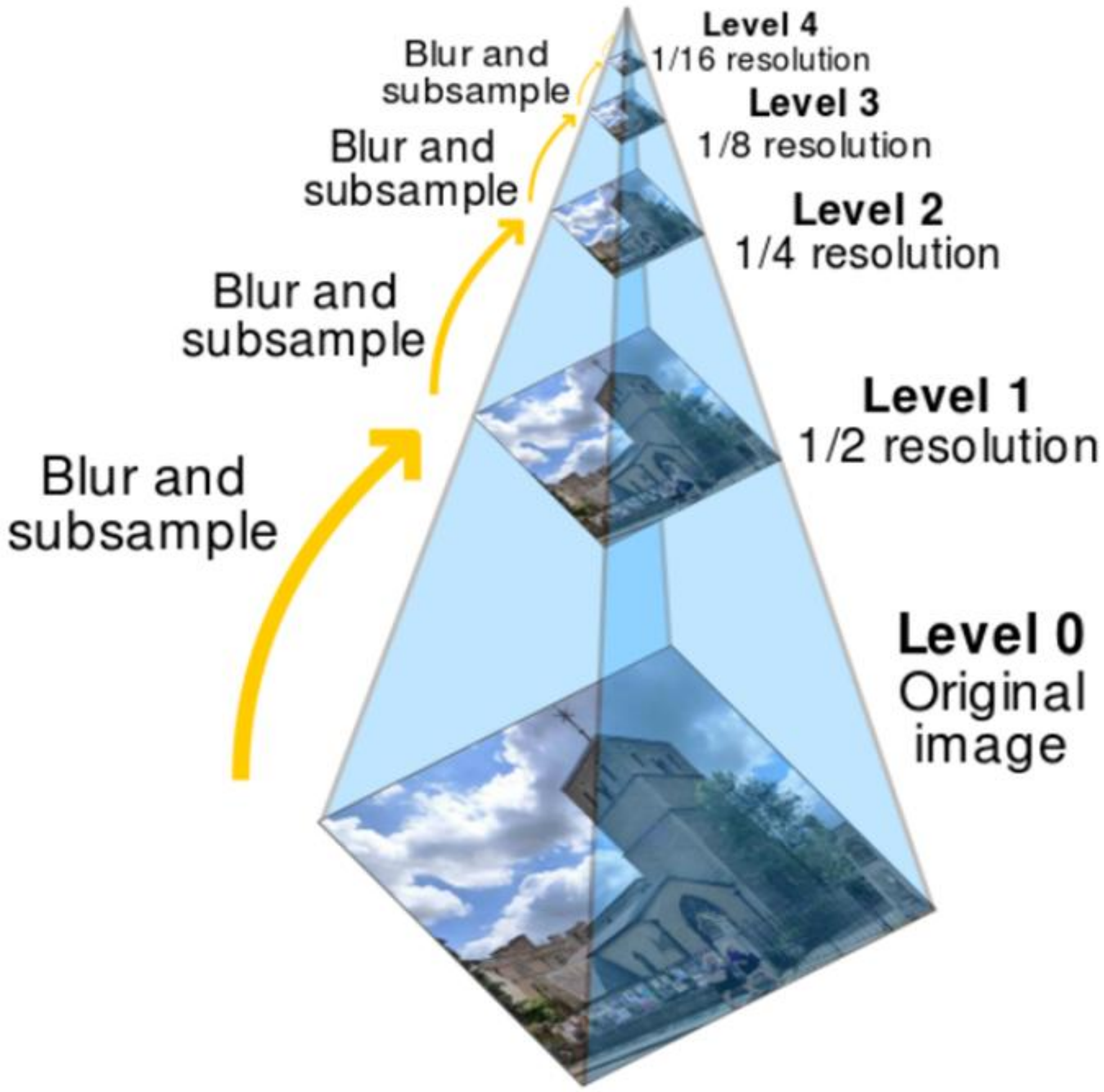


Image Scaling

- Assume that the image is too big for practical use:
  - Requires too much memory
  - Time consuming to process
  - Too big for the screen
  - …
- A smaller image can be obtained by image sub-sampling

Image Downsampling

1/2

1/4

1/8

Throw away every other row and column → image reduced to ½ size along each dimension.

Image Downsampling

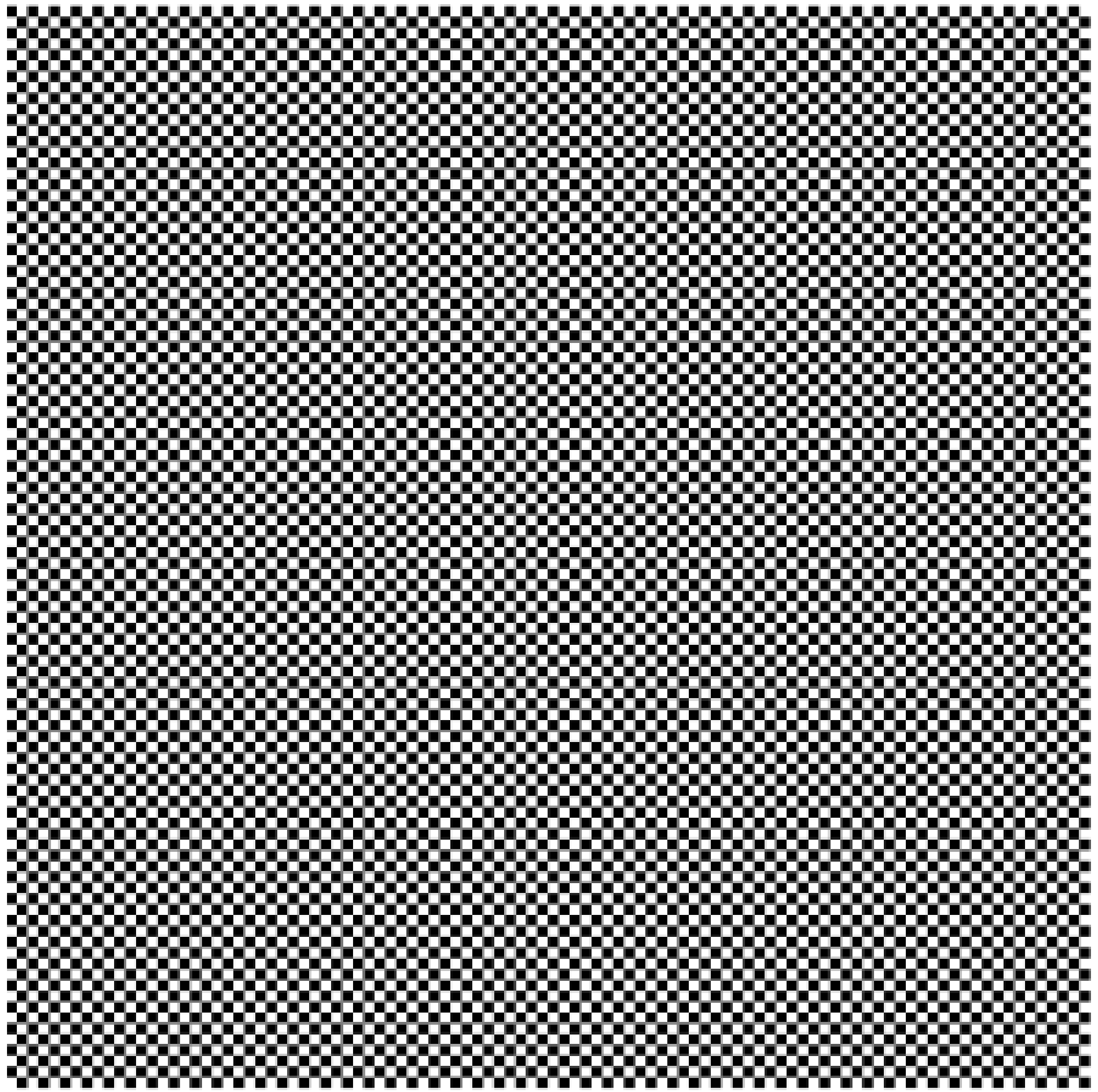
1/2

1/4 (2x zoom)

1/8 (4x zoom)

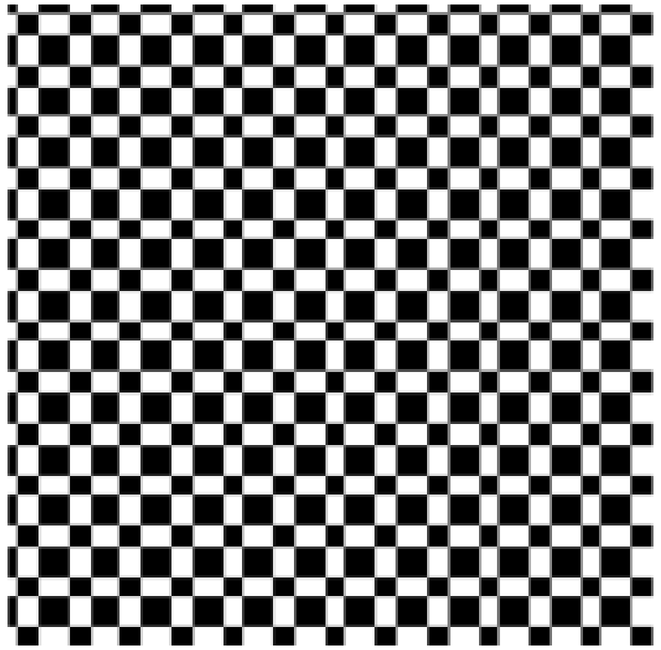
The subsampled images are of low quality. Why?

Spatial Undersampling

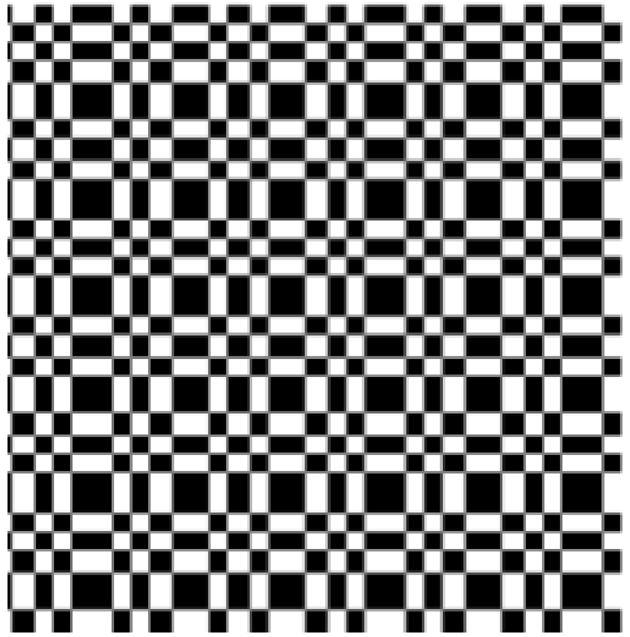


Checkerboard with 10 x 10 pixel squares

Downsampled images



1/10

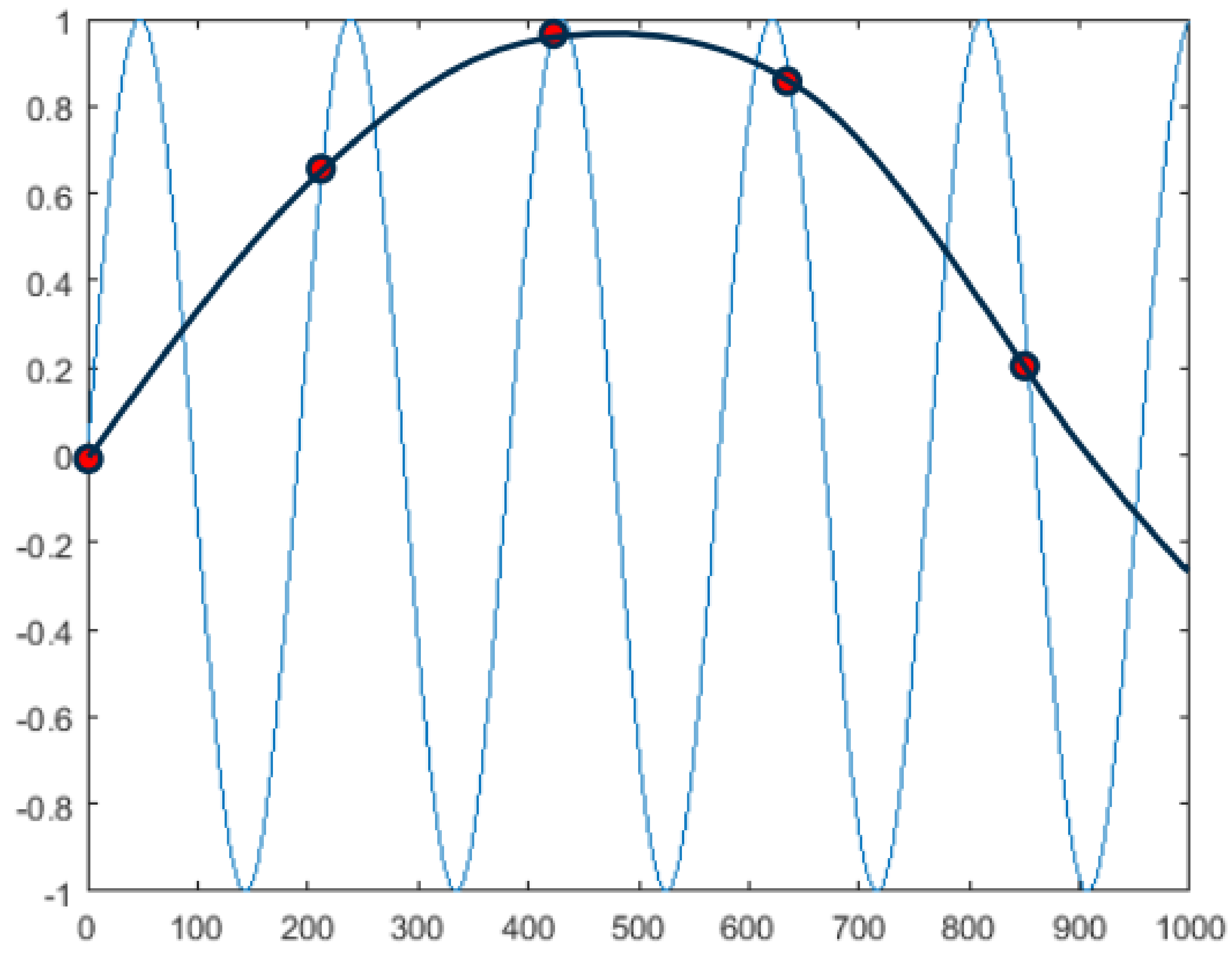


1/16

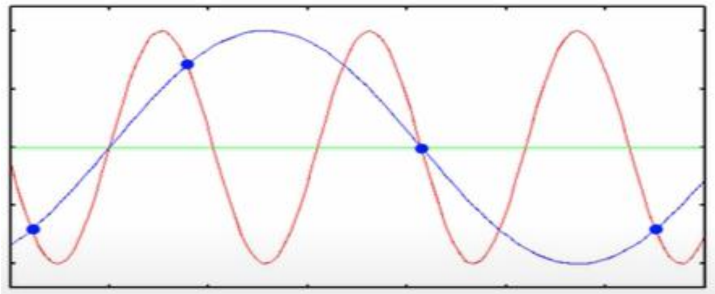
Aliasing

- Occurs when the (spatial) sampling rate is not high enough to capture the details in the image
- High frequencies are transformed to lower frequencies (i.e. aliases)
- To avoid aliasing the sampling rate must be at least two times the maximum frequency in the image (at least two samples per cycle)
- This minimum sampling rate is called the **Nyquist rate**.

Aliasing can be avoided by low-pass filtering the image before downsampling



Aliasing



Aliasing of a undersampled 1D sinusoidal signal

Aliasing of a undersampled 2D image

Aliasing problem of a downsampled image

Aliasing problem avoided by using band limiting Low Pass Filter.

Gaussian pre-filtering (low pass)

Gaussian 1/2

Gaussian 1/4

Gaussian 1/8

Gaussian pre-filtering (low pass)

Gaussian 1/2

Gaussian 1/4

Gaussian 1/8

Compared to downsampling without low-pass filtering…

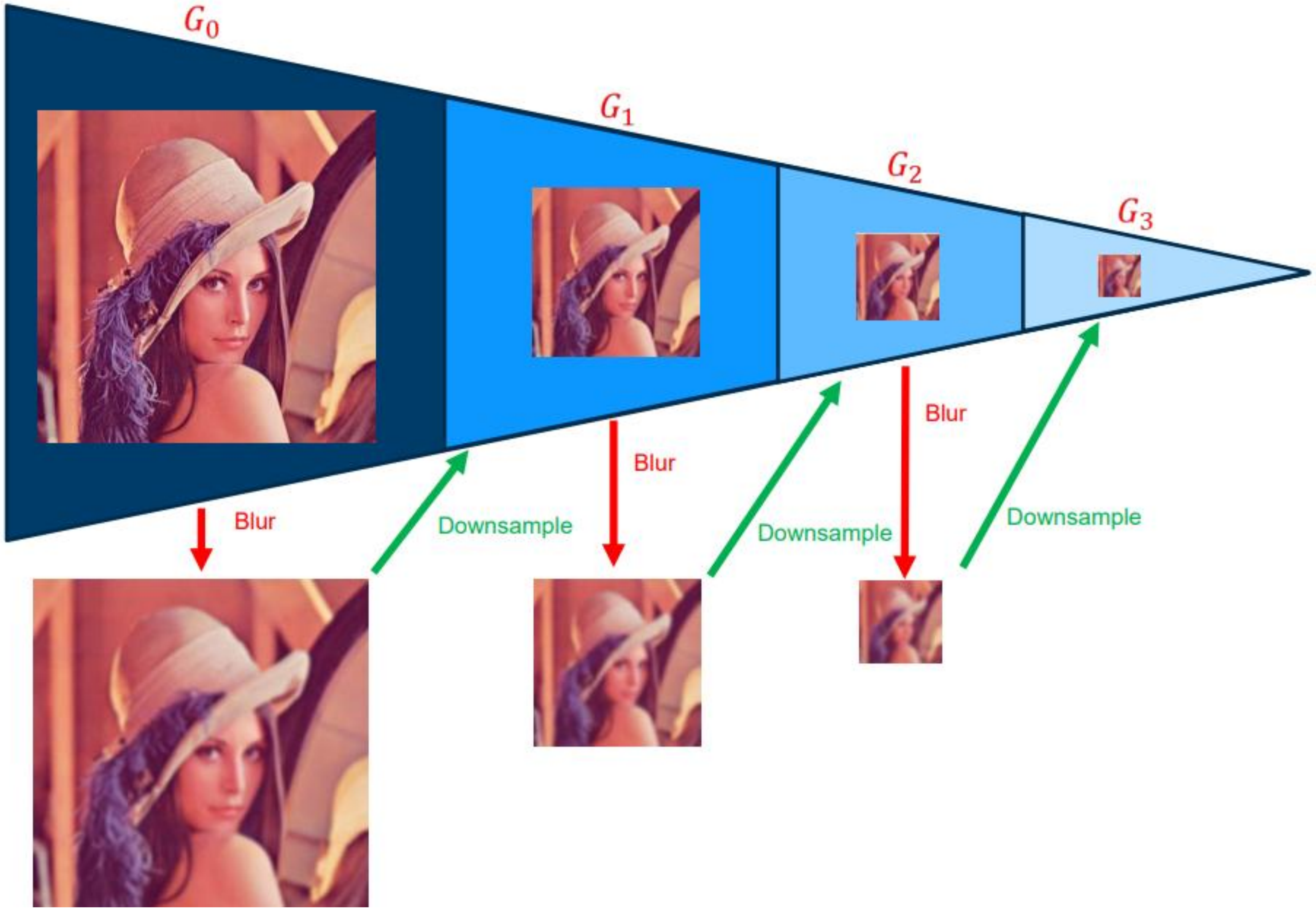
1/2

1/4

1/8

Conclusion: Low-pass filtering (i.e. smoothing with a Gaussian kernel) before subsampling the image!

Gaussian Pyramid



Upsampling

10 x magnification

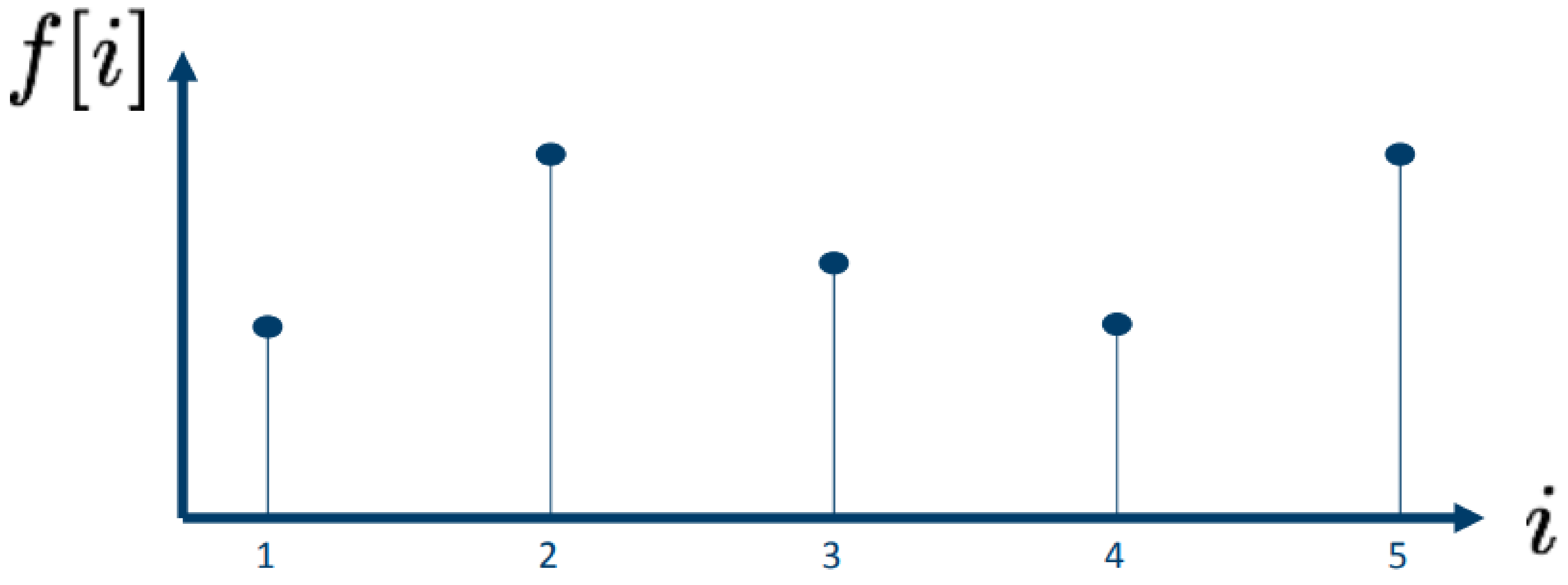
Nearest neighbor interpolation:

- Repeat each row and column 10 times
- Fast and simple approach.

Image interpolation

A digital image is a discrete point-sampling of a continuous function:

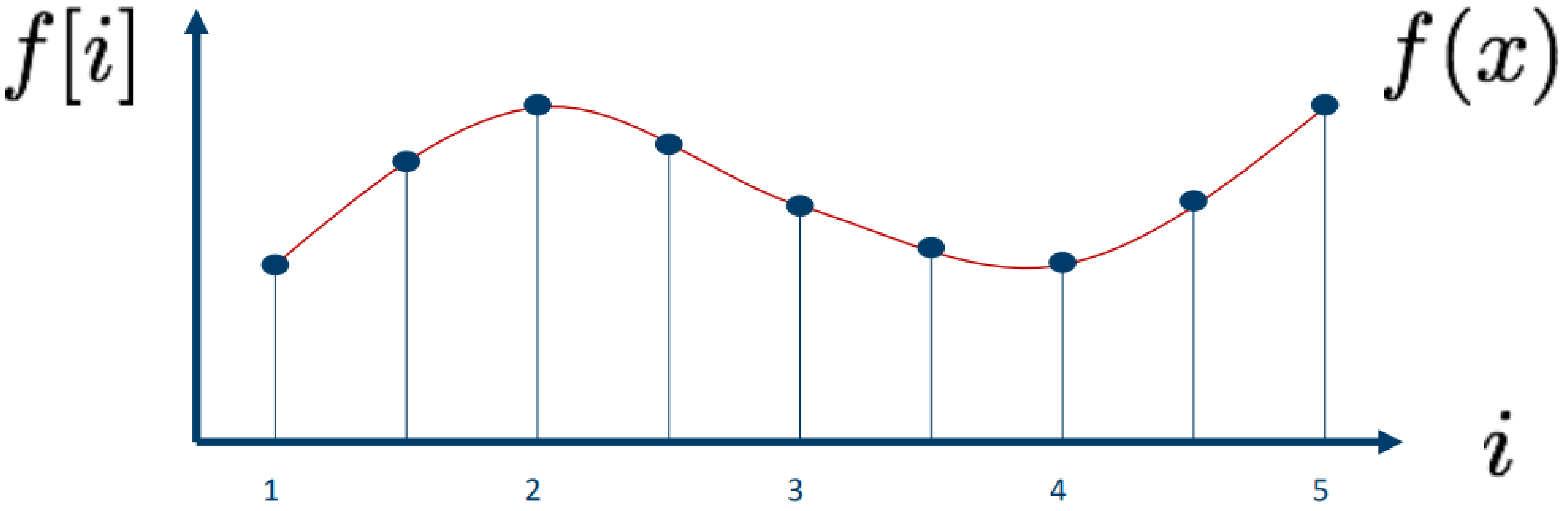
$$f[i,j] = quantize\{f(i\Delta x, j\Delta y)\} \quad \text{where} \quad x = i\Delta x \ \text{ and } \ y = i\Delta y$$



1D example

A new image could be generated, at any resolution and scale, if the original function could be reconstructed.

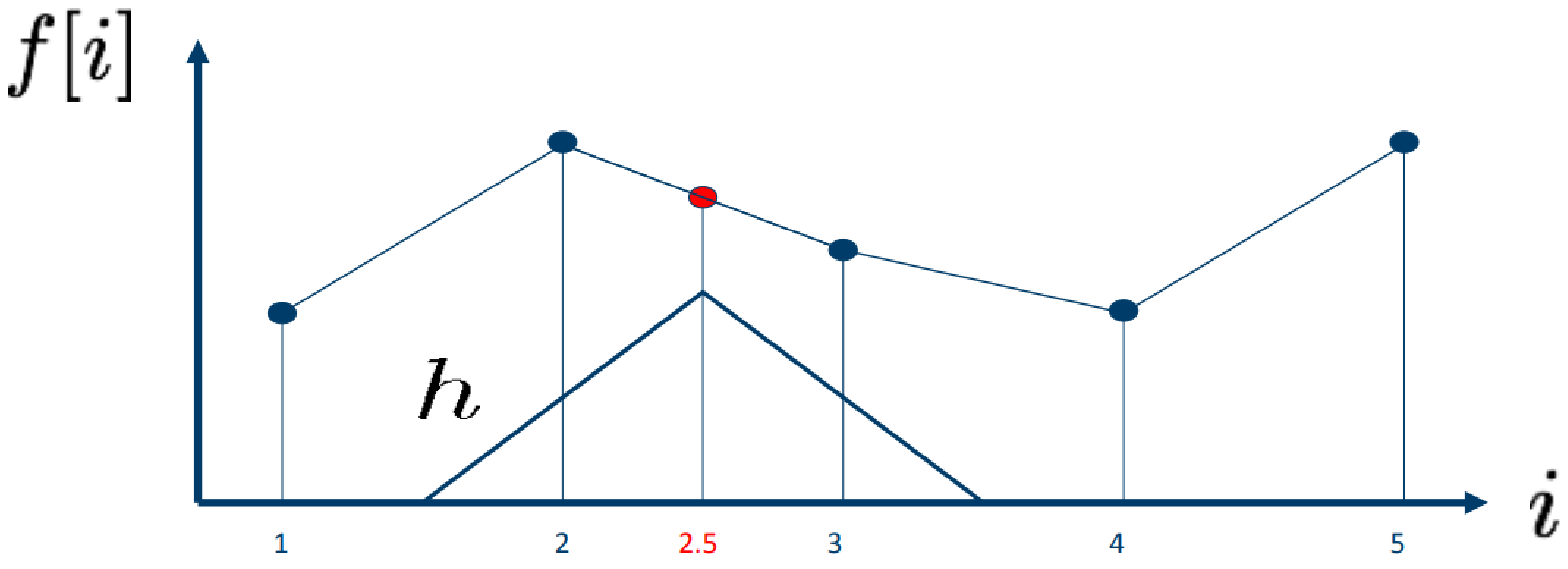
Interpolation by convolution



$$g[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} h[u,v] f[i-ru, j-rv]$$

r = scale factor

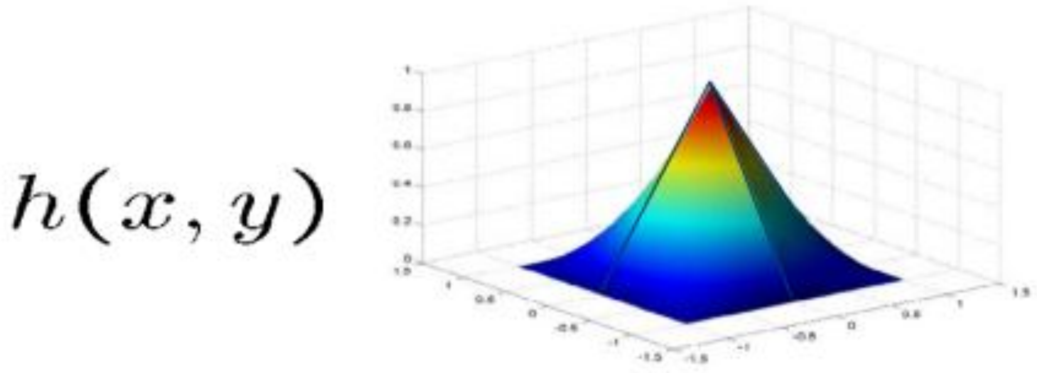
Linear interpolation (bilinear for images)



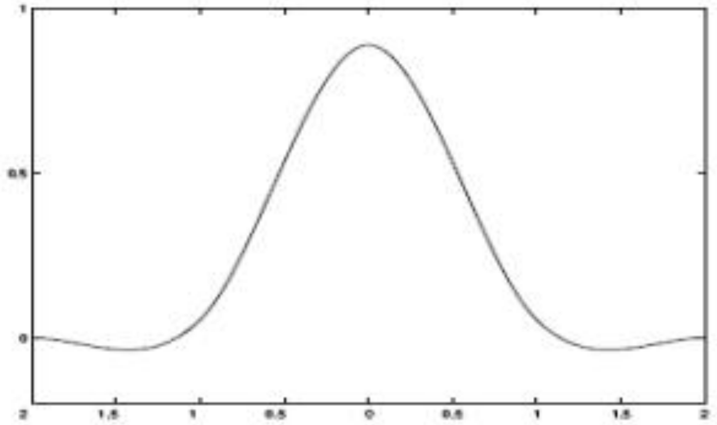
Some kernels for signal and image interpolation

Linear:

Bilinear:



Bicubic (better choice for images):



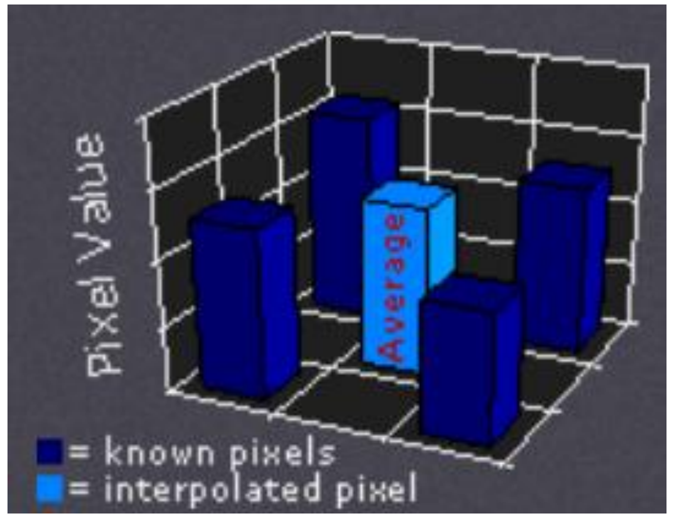
Nearest neighbor:

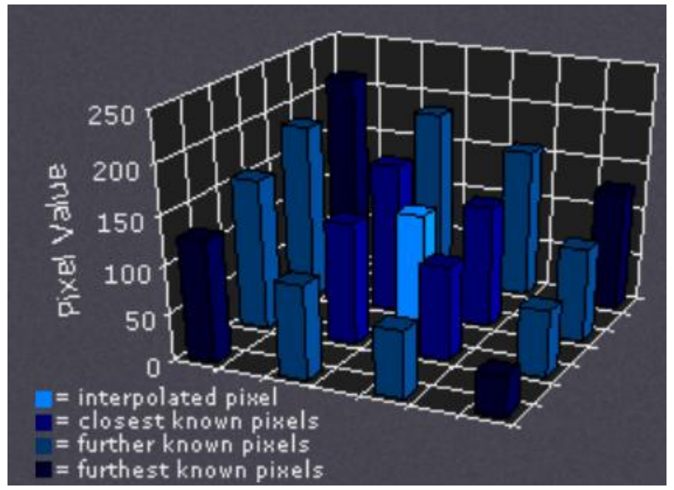
Image interpolation - examples

Nearest neighbor

Bilinear

Bicubic





It only considers one pixel — the closest one to the interpolated point.

This has the effect of simply making each pixel bigger.

Application: Template Matching with Image Pyramids

Input: Image, Template

1. Match template at current scale
2. Downsample image
3. Repeat 1-2 until image is very small
4. Take responses above some threshold, perhaps with non-maxima suppression.

Thank you!