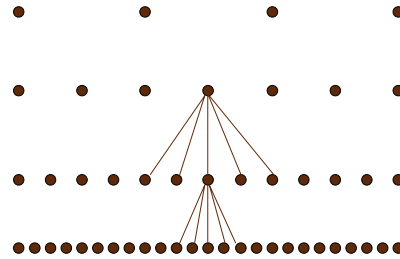


Image Pyramids

- Representation of images at multiple levels of resolution
- Importance - at different resolutions different features look differently
- Used for localization properties, motion computation and matching, biological motivation

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Pyramid construction



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Pyramid construction/reconstruction

- Take an original image - convolve with a blurring
 - Filter and subsample to get an image at lower resolution
- Reduction** - how is the signal at level l+1 related to level l

$$f^{l+1}[x, y] = \sum_{k=-\frac{w}{2}}^{\frac{w}{2}} \sum_{l=-\frac{w}{2}}^{\frac{w}{2}} g[k, l] f^l[2x - k, 2y - l]$$

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Pyramid construction/reconstruction

Expansion - how to reconstruct the signal at level l given related to level l-1 - notation

$$f^{l,k}[x, y]$$

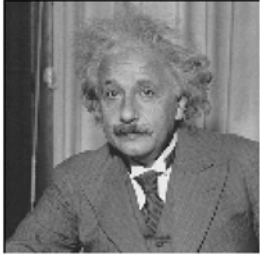
Signal at level l, expanded k - times

$$f^{l,k+1}[x, y] = \sum_{k=-\frac{w}{2}}^{\frac{w}{2}} \sum_{l=-\frac{w}{2}}^{\frac{w}{2}} c[k, l] f^l[(x - k)/2, (y - l)/2]$$

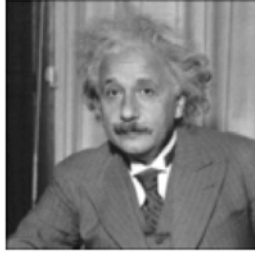
Idea - take the smaller signal fill every second entry
With zero and convolve with the blurring filter

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"Drop" vs "Smooth and Drop"



Drop every second pixel

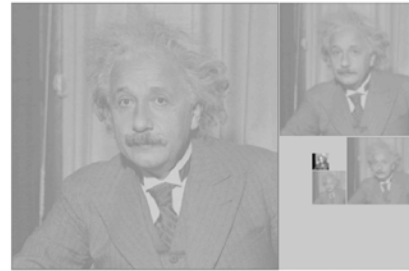


Smooth and Drop every second pixel

Aliasing problems

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Gaussian Pyramid



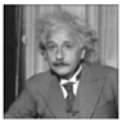
Consecutive smoothing and sub-sampling

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Laplacian Pyramid

Idea

when we convolve and down-sample some information will get lost i.e. if we reverse the process we cannot get the original image back. Example:



Blurred image of
Lower resolution



(original image - upsampled blurred image)
they are not the same - fine details are lost

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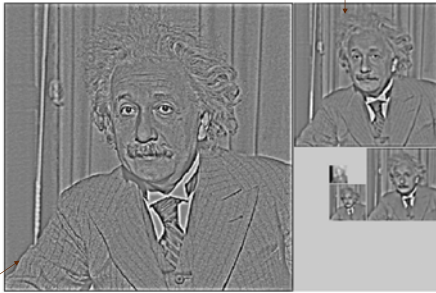
Laplacian pyramid

- Store the fine differences which get lost
- Each level of the Laplacian pyramid difference between two consecutive levels of gaussian pyramids

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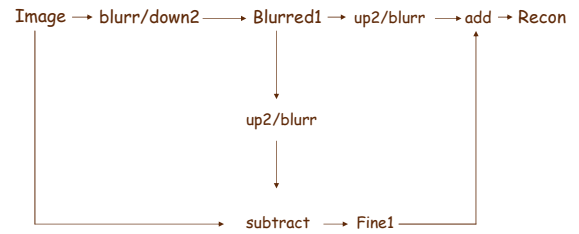
Laplacian Pyramid

blurred1 image - upsampled blurred2 image



original image - original image smoothed by gaussian

Schematic for construction/reconstruction



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Laplacian pyramids

- Laplacian pyramids - each level holds the additional information which is needed for better resolution
- We can obtain same image by convolving the image with difference of Gaussians filter or appropriate width
- Reflects the similarity between difference of Gaussians DoG and Laplacian operator introduced in the edge detection stage

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