Chapter 2 – Image Pyramids

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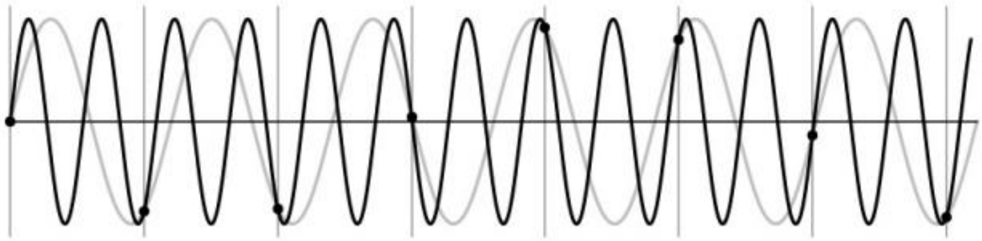
1. Image downsampling

We might have a too large image and we would like to downsample it.
Naïve image downsampling uses a strategy which deletes even rows and even columns such that the image gets downsampled, at cost of an image which gets more pixelated the more we downsample it.
This phenomenon is called “Spatial undersampling”.

1.1 Aliasing

If we consider a sinusoid which has multiple points, we might take fewer points but, in that case, information is lost, but we can still fool and confuse the signal with one of lower frequency.



That’s where Aliasing comes to play, since it is a term which indicates that different signals become indistinguishable (or aliases of one another) when sampled. The image above is a clear example.
A contrary effect of Aliasing is called “moire” which confuses a lot the human eye.
An alternative approach is oversampling the samples (**Anti-aliasing** by oversampling) or we can smooth the signal by removing some of the detail effects that cause aliasing. This will let us lose some information, but it’s worth a try for overcoming aliasing artifacts.
The second approach (smoothing) is really simple since, contrary to Naïve image downsampling, before removing rows and columns, we apply a smoothing filter (such as Gaussian) which can help us identify better the image when it’s downsampled.

2. Gaussian Image Pyramid

The strategy for the Gaussian Image Pyramid is to progressively reduce the number of pixels as we smooth more and more, leading to some sort of “Pyramid” representation.
The algorithm is structured as follows: Smooth image with a Gaussian -> Downsample -> Repeat.
Some properties of the Gaussian Pyramid involve the fact that the details of the image get smoothed out as we move to higher levels and that large uniform regions get preserved at higher levels.

3. Laplacian Image Pyramid

In the Laplacian Image Pyramid, at each level we retain the residuals instead of the blurred images (as we did in Gaussian). In this way we can reconstruct the original image using the Pyramid (which was not possible in Gaussian)
The algorithm is structured as follows:
Apply filter -> Compute residual -> Subsample image
We repeat this process until we reach a minimum resolution chosen by us.
It’s interesting to see how if we remove the “Compute residual” part, it’s essentially a Gaussian Pyramid.

In order to reconstruct the image, we have to upsample it and sum with residual until the original resolution is reached

3.1 Image blending

- Build Laplacian Pyramid for both images: LA, LB
- Build Gaussian Pyramid for mask: G
- Build a combined Laplacian Pyramid: $L(j) = G(j) * LA(j) + (1 – G(j)) * LB(j)$
- Collapse L to obtain the blended image