The Laplacian Pyramid

The general class of linear transform decomposes an image into various components by multiplication with a set of transform functions. Some examples are the Discrete Fourier and Discrete Cosine Transforms, the Singular Value Decomposition, and finally, the Wavelet Transform, of which the Laplacian Pyramid and other subband transforms are simple ancestors.

Real-world digital images are in general both scale-variant and highly nonstationary in space. They contain a variety of objects and features (lines, shapes, patterns, edges) at differerent scales, orientations, and spatial locations; features which the ideal image transformation should independently extract into easily manipulable components ().

The Laplacian Pyramid decomposition, originally developed by Burt and Adelson , is illustrated in Figure 1 for a two-level pyramid. The following pseudocode describes the simple process for a pyramid with an arbitrary number of levels.

```
g = makeGaussianFilt()
do( i = 0 : nScales-1 ) {

= subSamp2( l_i)

}
output:
```

Notice from the pseudocode that the pyramid consists of `nScales` ``highpass'' bands $h_i$ and a ``lowpass'' band, .The h_i contain most of the image's important textural features, at different scales. The Laplacian Pyramid is named as such because the process of computing h_i by subtracting a blurred copy f_i from f_i is equivalent to convolving f_i with (approximately) the Laplacian of the Gaussian blurring filter.
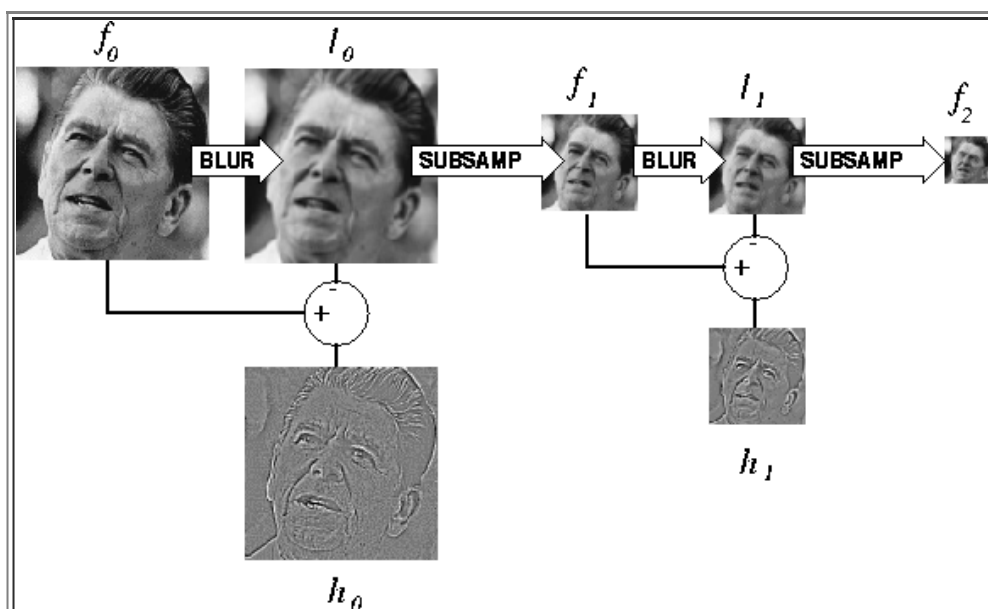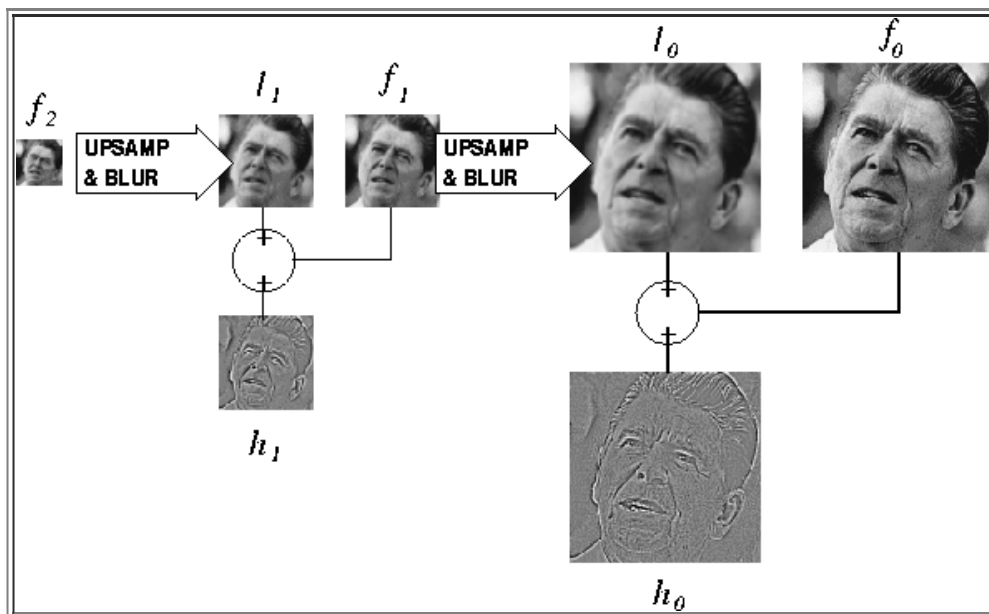
Figure 1 Decomposition step for two-level Laplacian Pyramid. The finished pyramid consists of the two ``highpass'' bands, $h_0$ and $h_1$, and the ``lowpass'' band, f_2.

The reconstruction step for a two-level Laplacian Pyramid proceeds in predictable faction, and is illustrated in figure [2](#). The following pseudocode describes the process for a pyramid with an arbitrary number of scales.

```
g = makeGaussianFilt()
do( i = nScales:-1:2 ) {
upSamp2( f_i )

}
output: f_0
```

The function `upSamp2()` simply inserts zeros between the samples of f_i, raising its size by a factor of two.

Figure 2 Reconstruction step for two-level Laplacian Pyramid. The process begins with the two ``highpass'' bands, $h_0$ and $h_1$, and the ``lowpass'' band, f_2, and then perfectly reconstructs the starting image, f_0.

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