Vivek Rathi

Rakshita R

Soumya Chintalapudi

PROJECT 04

For feature tracking, we need features which are invariant to affine transformations. Laplacian blob detector is one of the basic methods which generates features that are invariant to scaling.

The idea of a Laplacian blob detector is to convolve the image with a "blob filter" at multiple scales and look for extrema of filter response in the resulting scale space.

Blob Filter:

This filter is generated by double derivation of Gaussian filter along x and y-axis and adding them, also known as Laplacian of Gaussian.

$$LoG(x,y) = -\frac{1}{\pi\sigma^4}\left[1 - \frac{x^2+y^2}{2\sigma^2}\right]e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Unlike first-order filters that detect the edges based on local maxima or minima, Laplacian detects the edges at zero crossings i.e. where the value changes from negative to positive and vice-versa.

The function takes in σ as input and generates a filter of size k.

Scale space representation and filtering:

- **Changing kernel size**
  The above filter is made dynamic by varying its size as
  k= 0.4+(0.5* σ).
- **Scale-normalization**
  The response of a derivative of Gaussian filter to a perfect step edge decreases as σ increases. To keep response the same (scale-invariant), must multiply Gaussian derivative by σ. Laplacian is the second Gaussian derivative, so it must be multiplied by σ^2.
- **Taking squares of Laplacian response for current level of scale space**
  Consider convolution of the Laplacian filter with an image segment, both of same length. This would result in a response which looks like an inverted peak which zero crosses. That means we have obtained the

minima, but when we square the response, we get the maxima peak as required.

- **Convolution with Gaussian filters of changing σ values**
  The image is convolved with scale-normalized Laplacian at different values of σ's. σ is multiplied by (k^i) where i ranges from zero to nine.
- **Finding maximum peak**
  At each pixel of the squared Laplacian response, 3×3 neighbourhood is considered in all scales which gives the 9x3x3 matrix. The maximum peak of the matrix is given by the maximum value of the matrix. For every pixel, there will be a maximum.

Thresholding, Non-maximum suppression:

Not all pixels contribute to blobs. So, we need to eliminate them by thresholding the peaks. This threshold is found by trial and error method. If the maximum value is greater than the threshold then the point is considered, and coordinate is stored. After doing this we notice that there is still some overlapping of blobs. These are removed by non-maximum suppression. The area of overlap between the blobs is computed. A threshold is fixed. If the overlapping area is greater than the fixed threshold, the blob with smaller radius is suppressed.

Drawing blobs:

The Laplacian archives maximum response for the binary circle of radius r is at σ=1.414*r. These points are then taken to be centres of the required circles (the blob is drawn at each point in the stored list), and thus the blobs are plotted on the image.