Digital Imaging Systems
ECE 558
Project

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ALGORITHM:

1) **Generate a Laplacian of Gaussian filter.**

The function for a 2D Laplacian of Gaussian is given as:

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

This function is used to create a 2-dimensional Laplacian of Gaussian filter which is basically the 2nd derivative of a Gaussian.

2) **Build a Laplacian scale space, starting with some initial scale and going for n iterations:**

The function given above is used to create a Laplacian scale space of filters with varying sigma values which are then convoluted with the original image.

   a. **Filter image with scale-normalized Laplacian at current scale.**

In this step, we filter the image with the Laplacian of Gaussian (LoG) filters by the process of convolution with padding. In this case, the padding depends on the size of each of the LoG filters.

   b. **Save square of Laplacian response for current level of scale space.**

The square of the convoluted image is taken for each element in order to bring up the negative lower values to the positive scale. This makes a negative intensity value of -5 at the same level as a positive 5 intensity level. This eliminates the need to perform non-maxima suppression.

   c. **Increase scale by a factor *k*.**

The above two steps are performed n number of times to create a Laplacian scale space with varying sigma values. The number of levels in the scale space, n is a parameter that depends on the application. Therefore, the standard deviation for the n^{th} level is taken as $\sigma * k^n$. The size of each of these filters depends on the standard deviation that has been calculated using the formula given.

3) **Perform non-maximum suppression in scale space.**

Non-maximum suppression is performed in each level of the scale space by analyzing all the neighbors of all the elements. A pixel is therefore considered a blob only when that pixel has the lowest intensity in comparison to all its neighbors. In this case, boundary conditions must be applied for the first and last levels including the edge and corner pixels for all the levels of the scale space.

4) **Display resulting circles at their characteristic scales.**

The blobs in the images are shown using circles with radius that depends on the level and centers where the blobs have been detected.

PARAMETERS:

No. of levels:

The number of levels in the scale space is taken as 15. This is selected in order to balance between the size of blobs to be detected and the time taken for computation.

Standard Deviation (σ):

Standard deviation is a representation of the radius of the Laplacian of Gaussian filter. This bounds the maximum and minimum size of blobs to be detected along with the number of scale spaces. A standard deviation of 0.707 was selected.

k:

A k value of 1.24 was selected for this project.

Radius of circles:

The radius of the circles that are drawn to show the blobs are calculated using the formula $\sqrt{2} * \sigma(n)$.

RESULTS:

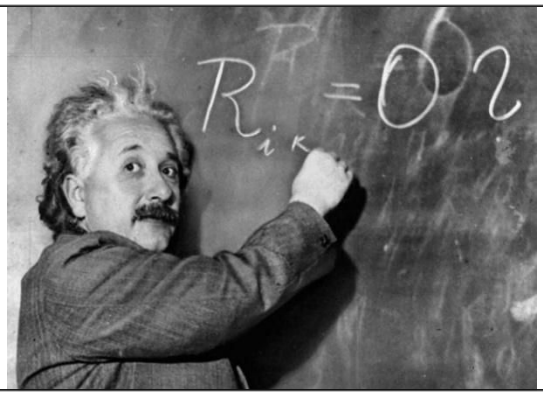
Filter response

Original Image

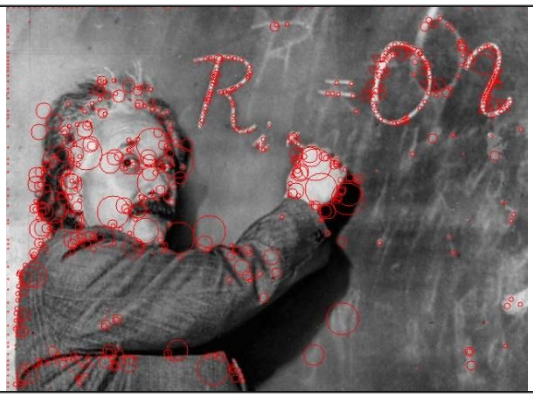
Filtered Image (level = 9)

Blob detection

Original Image



Blob detected Image



Original Image

Blob detected Image

Original Image

Blob detected Image

Original Image

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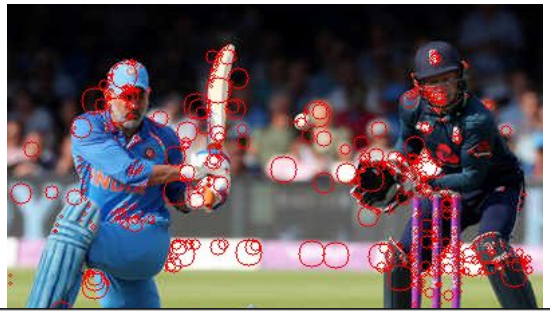
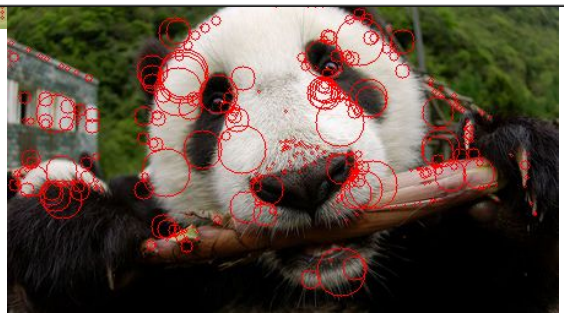
Original Image

Blob detected Image



Original Image

Blob detected Image



Original Image

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