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I have scaled the image to be of size 0.3 times the original image, for faster processing.

- 1. a) Design a Gaussian filter kernel of size 9x9
- Gaussian with standard deviation = 1

```
1.791e-08 | 5.931e-07 | 7.226e-06 | 3.238e-05 | 5.339e-05 | 3.238e-05 | 7.226e-06 | 5.931e-07 | 1.791e-08 | 5.931e-07 | 1.964e-05 | 2.393e-04 | 1.072e-03 | 1.768e-03 | 1.072e-03 | 2.393e-04 | 1.964e-05 | 5.931e-07 | 7.226e-06 | 2.393e-04 | 2.915e-03 | 1.306e-02 | 2.154e-02 | 1.306e-02 | 2.915e-03 | 2.393e-04 | 7.226e-06 | 3.238e-05 | 1.072e-03 | 1.306e-02 | 5.855e-02 | 9.653e-02 | 5.855e-02 | 1.306e-02 | 1.072e-03 | 3.238e-05 | 5.339e-05 | 1.768e-03 | 2.154e-02 | 9.653e-02 | 1.592e-01 | 9.653e-02 | 2.154e-02 | 1.768e-03 | 5.339e-05 | 3.238e-05 | 1.072e-03 | 1.306e-02 | 5.855e-02 | 9.653e-02 | 5.855e-02 | 1.306e-02 | 1.072e-03 | 3.238e-05 | 7.226e-06 | 2.393e-04 | 2.915e-03 | 1.306e-02 | 2.154e-02 | 1.306e-02 | 2.915e-03 | 2.393e-04 | 7.226e-06 | 5.931e-07 | 1.964e-05 | 2.393e-04 | 1.072e-03 | 1.768e-03 | 1.072e-03 | 2.393e-04 | 1.964e-05 | 5.931e-07 | 1.791e-08 | 5.931e-07 | 7.226e-06 | 3.238e-05 | 5.339e-05 | 3.238e-05 | 7.226e-06 | 5.931e-07 | 7.226e-06 | 3.238e-05 | 5.339e-05 | 3.238e-05 | 7.226e-06 | 5.931e-07 | 7.226e-06 | 3.238e-05 | 5.339e-05 | 3.238e-05 | 7.226e-06 | 5.931e-07 | 7.226e-06 | 3.238e-05 | 5.339e-05 | 3.238e-05 | 7.226e-06 | 5.931e-07 | 1.791e-08
```

• Gaussian with std = 3

```
3.965e-03 | 5.850e-03 | 7.723e-03 | 9.124e-03 | 9.645e-03 | 9.124e-03 | 7.723e-03 | 5.850e-03 | 3.965e-03 | 5.850e-03 | 8.631e-03 | 1.139e-02 | 1.346e-02 | 1.423e-02 | 1.346e-02 | 1.139e-02 | 8.631e-03 | 5.850e-03 | 7.723e-03 | 1.139e-02 | 1.504e-02 | 1.777e-02 | 1.879e-02 | 1.777e-02 | 1.504e-02 | 1.139e-02 | 7.723e-03 | 9.124e-03 | 1.346e-02 | 1.777e-02 | 2.099e-02 | 2.219e-02 | 2.099e-02 | 1.777e-02 | 1.346e-02 | 9.124e-03 | 9.645e-03 | 1.423e-02 | 1.879e-02 | 2.219e-02 | 2.219e-02 | 2.219e-02 | 1.879e-02 | 1.423e-02 | 9.645e-03 | 9.124e-03 | 1.346e-02 | 1.777e-02 | 2.099e-02 | 2.219e-02 | 2.099e-02 | 1.777e-02 | 1.346e-02 | 9.124e-03 | 7.723e-03 | 1.139e-02 | 1.504e-02 | 1.777e-02 | 1.879e-02 | 1.777e-02 | 1.504e-02 | 7.723e-03 | 5.850e-03 | 8.631e-03 | 1.139e-02 | 1.346e-02 | 1.423e-02 | 1.346e-02 | 1.139e-02 | 8.631e-03 | 5.850e-03 | 3.965e-03 | 5.850e-03 | 7.723e-03 | 7.723e-03 | 7.723e-03 | 7.723e-03 | 5.850e-03 | 3.965e-03 | 5.850e-03 | 5.850e-03 | 3.965e-03 | 5.850e-03 | 5.850e-03 | 3.965e-03 | 3.965e
```

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• Gaussian with std = 20

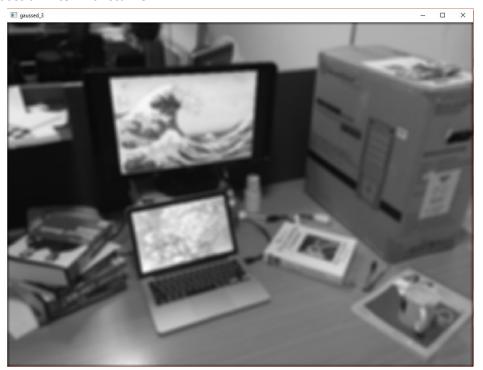
```
1.206e-02 | 1.217e-02 | 1.224e-02 | 1.229e-02 | 1.230e-02 | 1.229e-02 | 1.224e-02 | 1.217e-02 | 1.206e-02 | 1.217e-02 | 1.227e-02 | 1.235e-02 | 1.240e-02 | 1.241e-02 | 1.240e-02 | 1.235e-02 | 1.227e-02 | 1.217e-02 | 1.224e-02 | 1.235e-02 | 1.247e-02 | 1.229e-02 | 1.240e-02 | 1.247e-02 | 1.252e-02 | 1.254e-02 | 1.252e-02 | 1.247e-02 | 1.240e-02 | 1.230e-02 | 1.241e-02 | 1.249e-02 | 1.254e-02 | 1.255e-02 | 1.254e-02 | 1.249e-02 | 1.241e-02 | 1.230e-02 | 1.229e-02 | 1.240e-02 | 1.247e-02 | 1.252e-02 | 1.252e-02 | 1.252e-02 | 1.247e-02 | 1.240e-02 | 1.229e-02 | 1.229e-02 | 1.247e-02 | 1.235e-02 | 1.247e-02 | 1.247e
```

b) Perform Gaussian filtering on an image

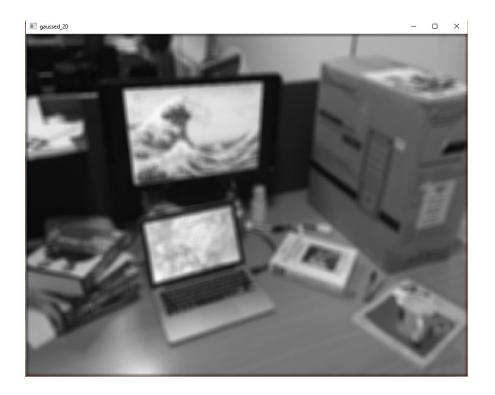
Filtering with Gaussian filter with std = 1



• Filtering with Gaussian filter with std = 3



• Filtering with Gaussian filter with std = 20



2. a) Design a DoG (Difference of Gaussians) filter of size 11x11 and standard deviations of your choice.

```
4.172e-04 | 8.571e-04 | 1.501e-03 | 2.238e-03 | 2.845e-03 | 3.082e-03 | 2.845e-03 | 2.238e-03 | 1.501e-03 | 8.571e-04 | 4.172e-04 | 8.571e-04 | 1.761e-03 | 3.082e-03 | 4.592e-03 | 5.817e-03 | 6.285e-03 | 5.817e-03 | 4.592e-03 | 3.082e-03 | 1.761e-03 | 8.571e-04 | 1.501e-03 | 3.082e-03 | 7.837e-03 | 9.276e-03 | 9.506e-03 | 9.276e-03 | 7.837e-03 | 3.082e-03 | 3.082e-03 | 1.501e-03 | 2.238e-03 | 4.592e-03 | 7.837e-03 | 9.403e-03 | 3.583e-03 | -2.726e-03 | 3.583e-03 | 9.403e-03 | 7.837e-03 | 4.592e-03 | 2.238e-03 | 2.238e-03 | 5.817e-03 | 9.276e-03 | 3.583e-03 | -2.726e-03 | 3.583e-03 | 9.276e-03 | 5.817e-03 | 5.817e-03 | 2.845e-03 | 3.082e-03 | 5.817e-03 | 2.238e-03 | 3.082e-03 | 5.817e-03 | 3.583e-03 | -2.726e-02 | -3.296e-02 | -3.296e-02 | -2.726e-03 | 9.506e-03 | 5.817e-03 | 2.845e-03 | 2.238e-03 | 3.583e-03 | 9.276e-03 | 3.583e-03 | 3.583e-03 | 9.276e-03 | 3.583e-03 | 3.082e-03 | 3.583e-03 | 3.2845e-03 | 3.2845e-0
```

b) Perform filtering on an image using DoG filter designed in part 2(a)



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c) Detect zero crossings and generate a binary image highlighting the zero crossings on the DoG filtered image.

Here I used a kernel that looks at 4 neighbors and if the pixel that it is looking at is +ve and if any of the neighbors are -ve than the pixel is turned to value 255, and all the rest of the pixels are set to 0. Below is the result.

