

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 | 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 | 2.346e-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 | 1.139e-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 | 9.124e-03 | 9.645e-03 | 9.124e-03 | 7.723e-03 | 5.850e-03 | 3.965e-03

- Gaussian with std = 20

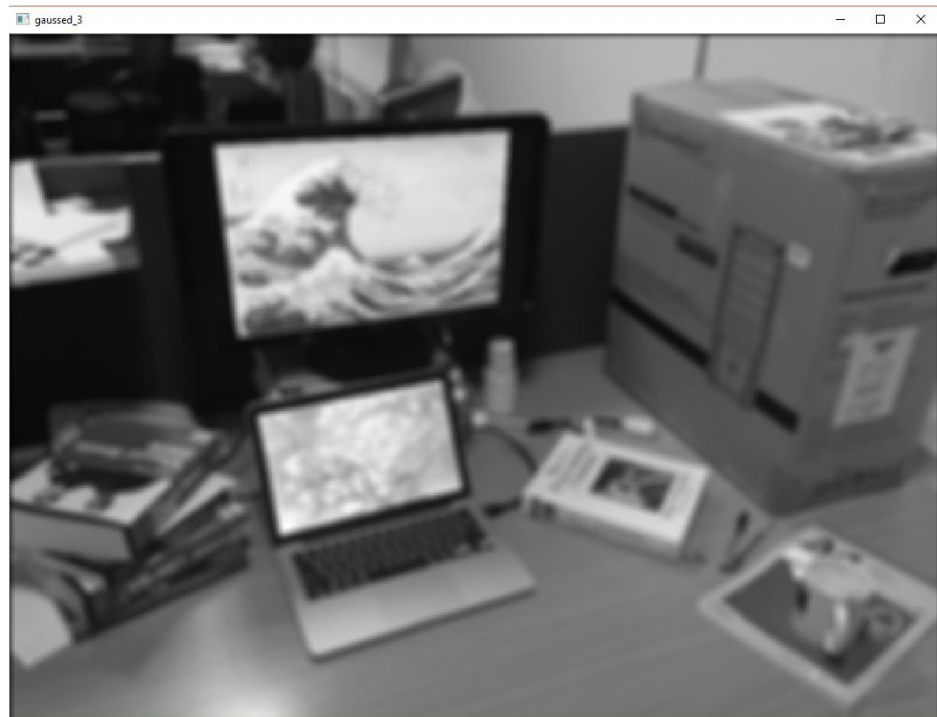
1.206e-02 | 1.217e-02 | 1.224e-02 | 1.229e-02 | 1.230e-02 | 1.229e-02 | 1.224e-02 | 1.217e-02 | 1.206e-02
1.217e-02 | 1.227e-02 | 1.235e-02 | 1.240e-02 | 1.241e-02 | 1.240e-02 | 1.235e-02 | 1.227e-02 | 1.217e-02
1.224e-02 | 1.235e-02 | 1.243e-02 | 1.247e-02 | 1.249e-02 | 1.247e-02 | 1.243e-02 | 1.235e-02 | 1.224e-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 | 1.229e-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 | 1.254e-02 | 1.252e-02 | 1.247e-02 | 1.240e-02 | 1.229e-02
1.224e-02 | 1.235e-02 | 1.243e-02 | 1.247e-02 | 1.249e-02 | 1.247e-02 | 1.243e-02 | 1.235e-02 | 1.224e-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
1.206e-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

b) Perform Gaussian filtering on an image

- Filtering with Gaussian filter with $\text{std} = 1$



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- Filtering with Gaussian filter with $\text{std} = 3$



- 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.

2.698e-03 | 2.157e-03 | 1.630e-03 | 1.187e-03 | 8.920e-04 | 7.885e-04 | 8.920e-04 | 1.187e-03 | 1.630e-03 | 2.157e-03 | 2.698e-03
2.157e-03 | 1.460e-03 | 7.885e-04 | 2.290e-04 | -1.423e-04 | -2.723e-04 | -1.423e-04 | 2.290e-04 | 7.885e-04 | 1.460e-03 | 2.157e-03
1.630e-03 | 7.885e-04 | -1.542e-05 | -6.824e-04 | -1.124e-03 | -1.278e-03 | -1.124e-03 | -6.824e-04 | -1.542e-05 | 7.885e-04 | 1.630e-03
1.187e-03 | 2.290e-04 | -6.824e-04 | -1.436e-03 | -1.934e-03 | -2.108e-03 | -1.934e-03 | -1.436e-03 | -6.824e-04 | 2.290e-04 | 1.187e-03
8.920e-04 | -1.423e-04 | -1.124e-03 | -1.934e-03 | -2.469e-03 | -2.656e-03 | -2.469e-03 | -1.934e-03 | -1.124e-03 | -1.423e-04 | 8.920e-04
7.885e-04 | -2.723e-04 | -1.278e-03 | -2.108e-03 | -2.656e-03 | -2.848e-03 | -2.656e-03 | -2.108e-03 | -1.278e-03 | -2.723e-04 | 7.885e-04
8.920e-04 | -1.423e-04 | -1.124e-03 | -1.934e-03 | -2.469e-03 | -2.656e-03 | -2.469e-03 | -1.934e-03 | -1.124e-03 | -1.423e-04 | 8.920e-04
1.187e-03 | 2.290e-04 | -6.824e-04 | -1.436e-03 | -1.934e-03 | -2.108e-03 | -1.934e-03 | -1.436e-03 | -6.824e-04 | 2.290e-04 | 1.187e-03
1.630e-03 | 7.885e-04 | -1.542e-05 | -6.824e-04 | -1.124e-03 | -1.278e-03 | -1.124e-03 | -6.824e-04 | -1.542e-05 | 7.885e-04 | 1.630e-03
2.157e-03 | 1.460e-03 | 7.885e-04 | 2.290e-04 | -1.423e-04 | -2.723e-04 | -1.423e-04 | 2.290e-04 | 7.885e-04 | 1.460e-03 | 2.157e-03
2.698e-03 | 2.157e-03 | 1.630e-03 | 1.187e-03 | 8.920e-04 | 7.885e-04 | 8.920e-04 | 1.187e-03 | 1.630e-03 | 2.157e-03 | 2.698e-03

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



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

