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Assignment 1

EE 645 3D Computer Vision

Q1 (a)The following figures show Gaussian kernels with standard deviation 1,3 and 20. We can see that at sigma = 20, the kernel nearly behaves as a average blur kernel.

Gaussian Filter Kernel Sigma-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 Filter Kernel Sigma-3

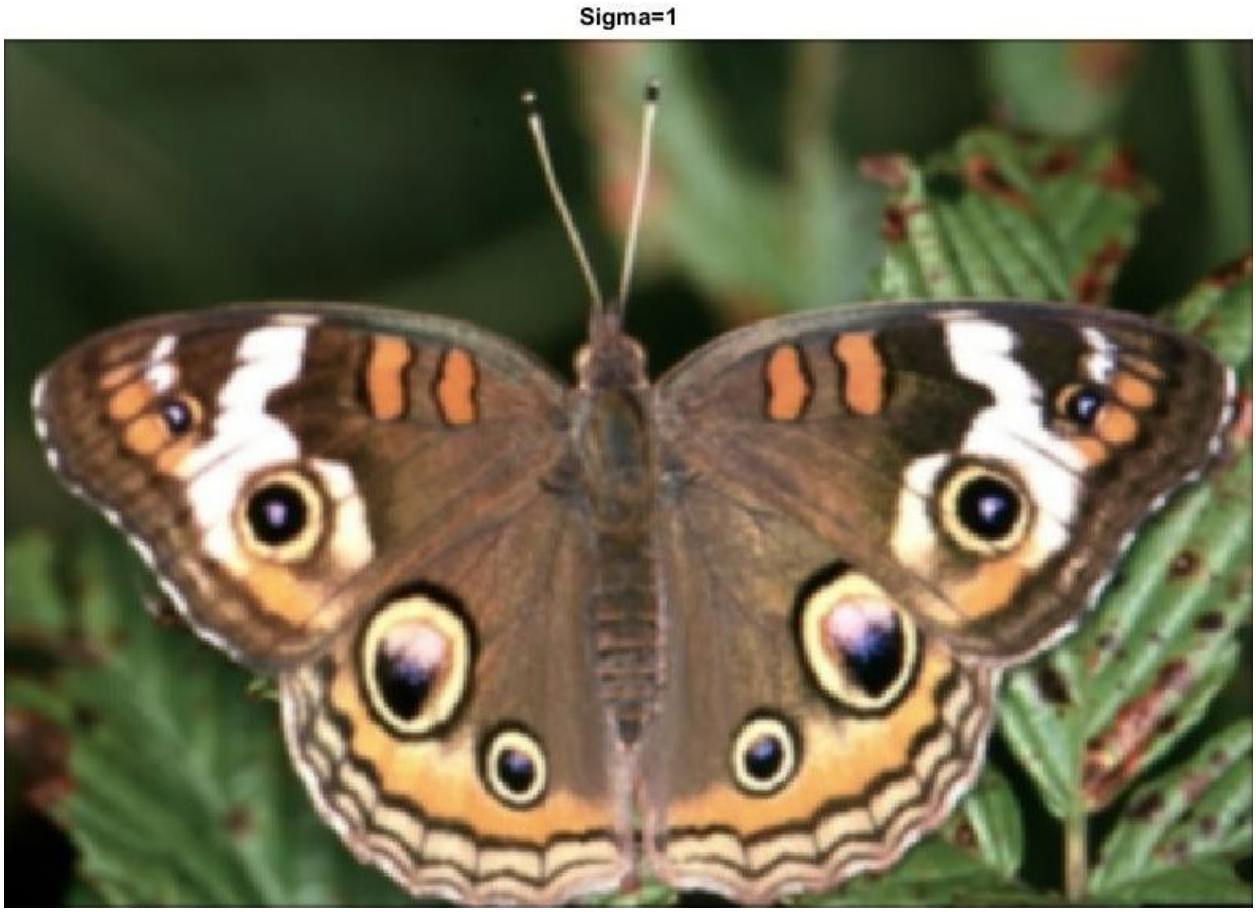
3.965e-03	5.850e-03	7.723e-03	9.124e-03	9.645e-03	9.124e-03	7.723e-03	5.850e-03	3.965e-03
5.850e-03	8.631e-03	1.139e-02	1.346e-02	1.423e-02	1.346e-02	1.139e-02	8.631e-03	5.850e-03
7.723e-03	1.139e-02	1.504e-02	1.777e-02	1.879e-02	1.777e-02	1.504e-02	1.139e-02	7.723e-03
9.124e-03	1.346e-02	1.777e-02	2.099e-02	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 Filter Kernel Sigma-20

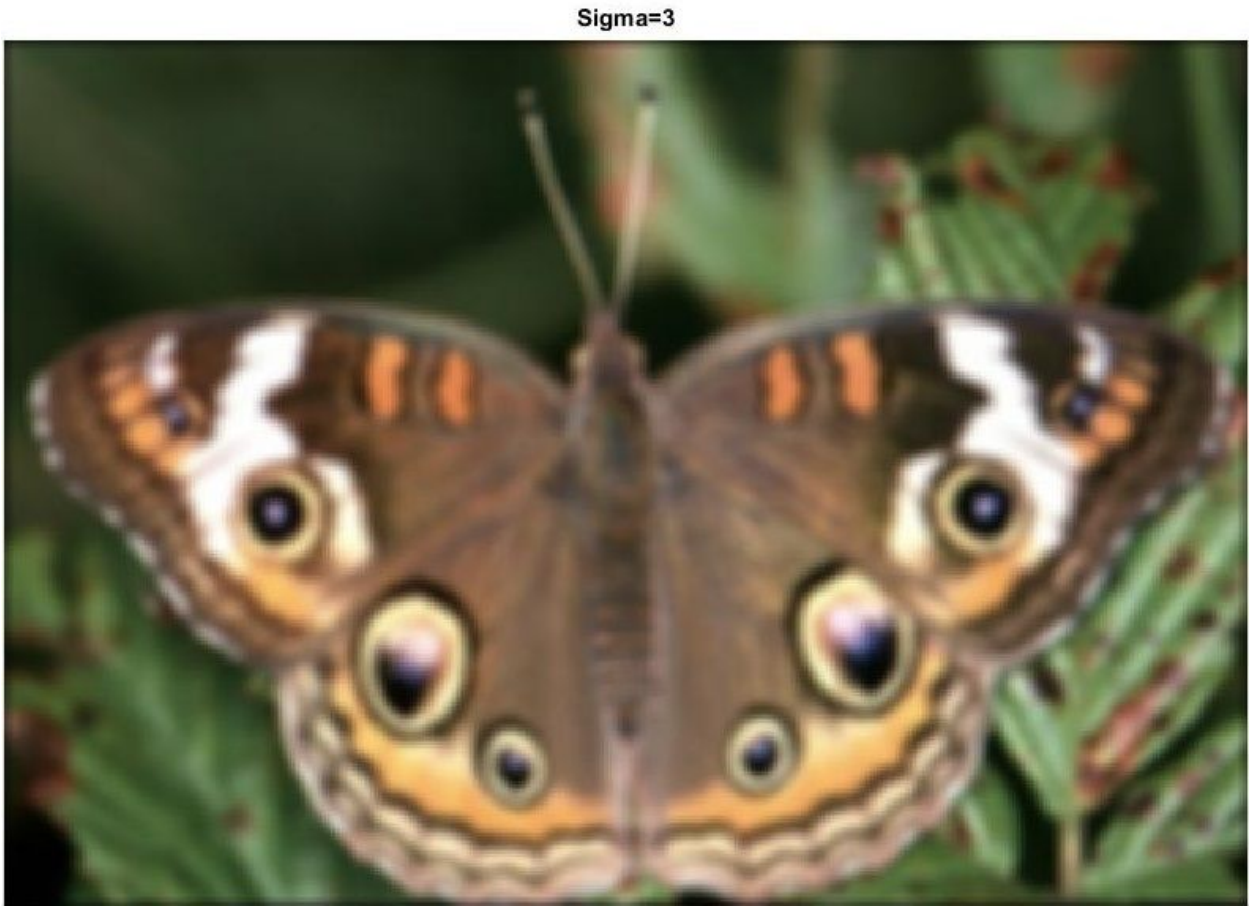
1.206e-02	1.217e-02	1.224e-02	1.229e-02	1.230e-02	1.229e-02	1.224e-02	1.217e-02	1.206e-02
1.217e-02	1.227e-02	1.235e-02	1.240e-02	1.241e-02	1.240e-02	1.235e-02	1.227e-02	1.217e-02
1.224e-02	1.235e-02	1.243e-02	1.247e-02	1.249e-02	1.247e-02	1.243e-02	1.235e-02	1.224e-02
1.229e-02	1.240e-02	1.247e-02	1.252e-02	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) The filtered images are shown below:

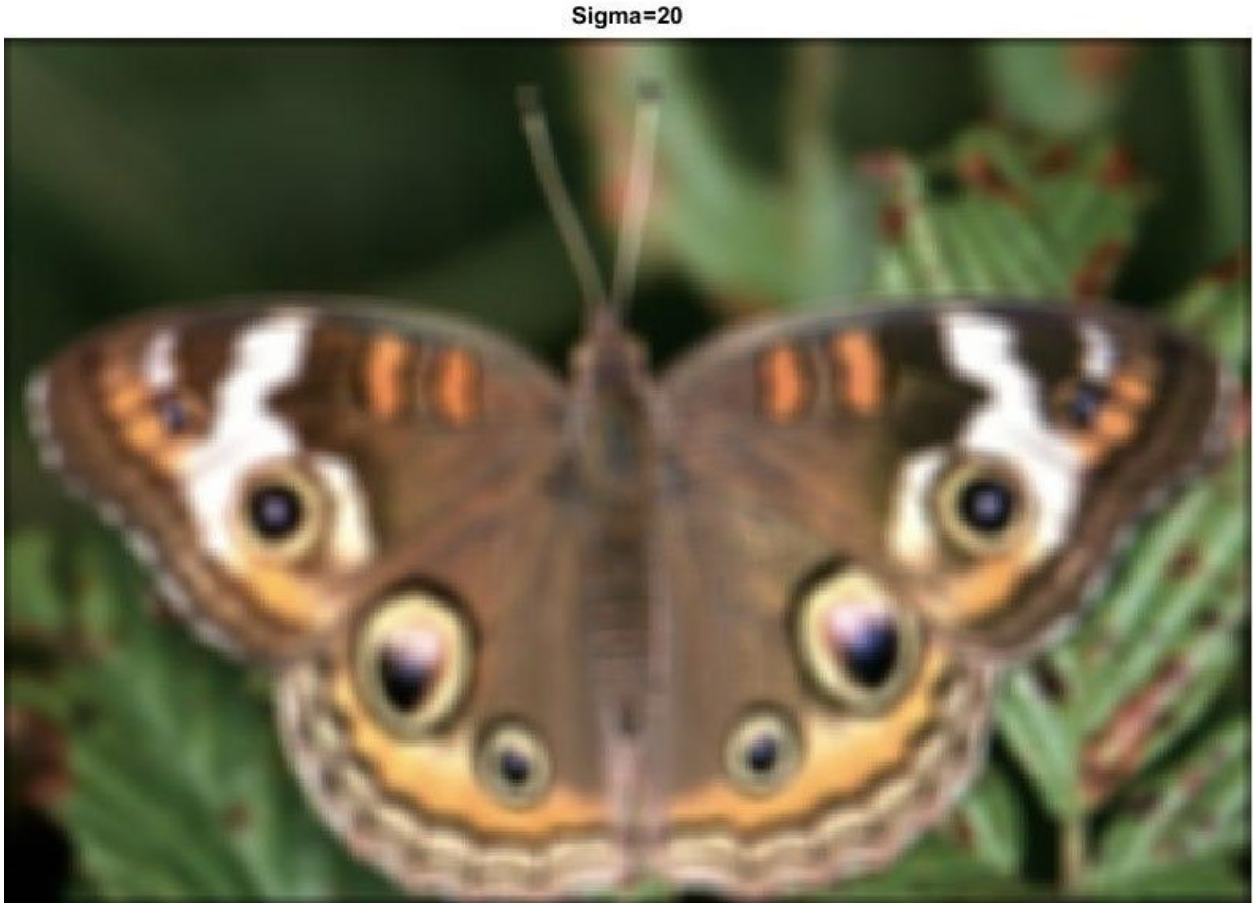
Original image



Filtered with sigma=1.



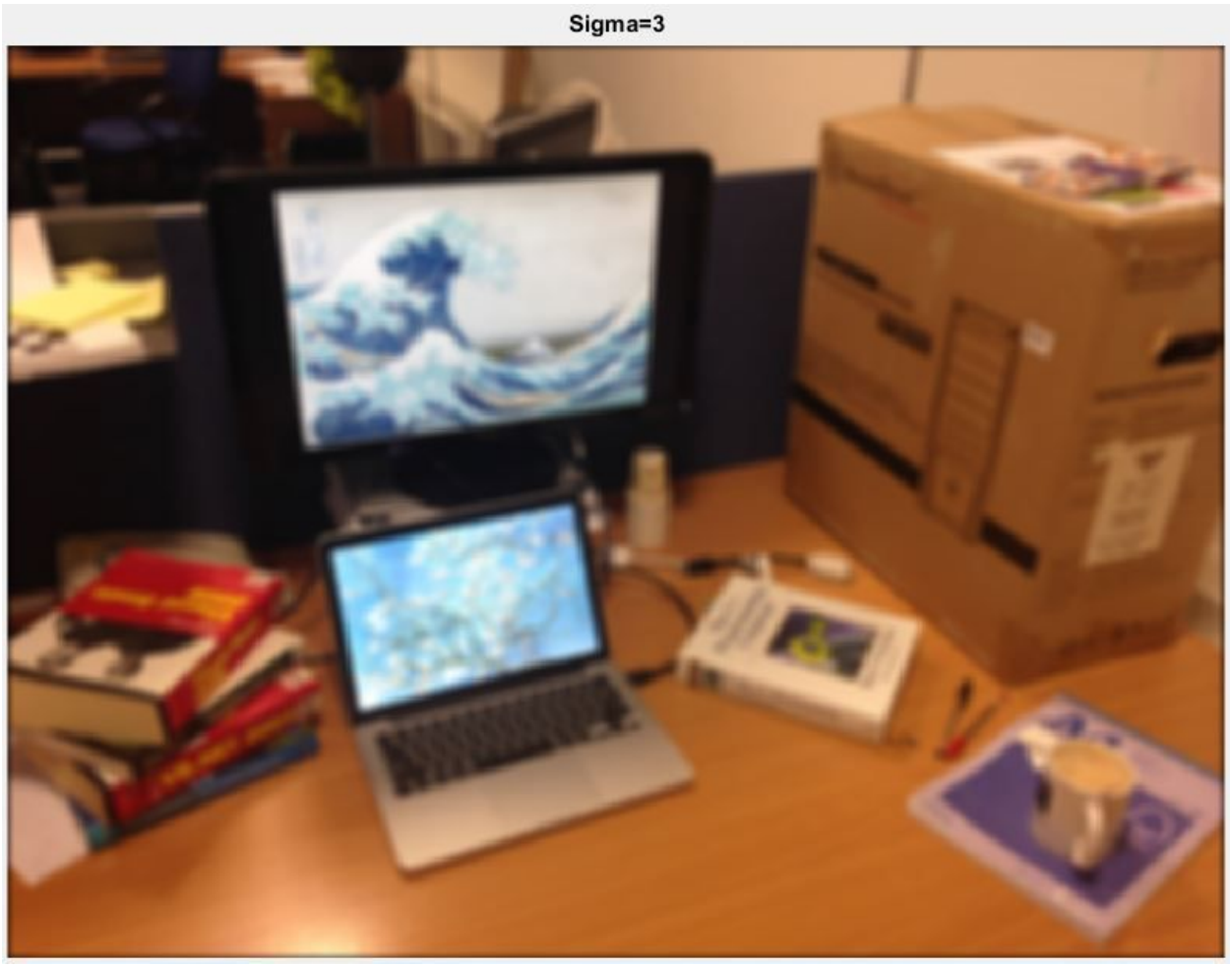
Filtered with sigma=3.



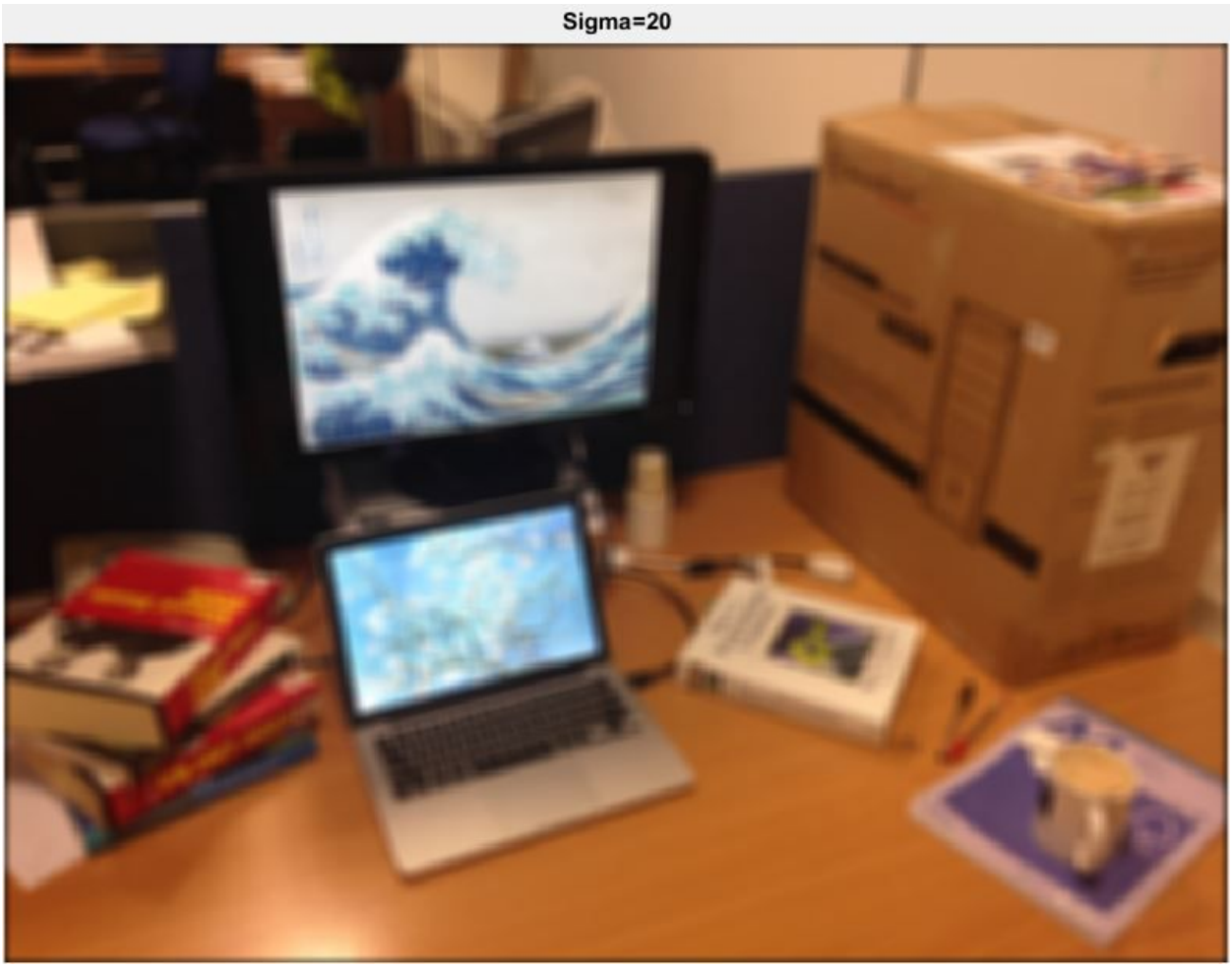
Filtered with sigma=20.

Original image

Filtered with sigma=1.



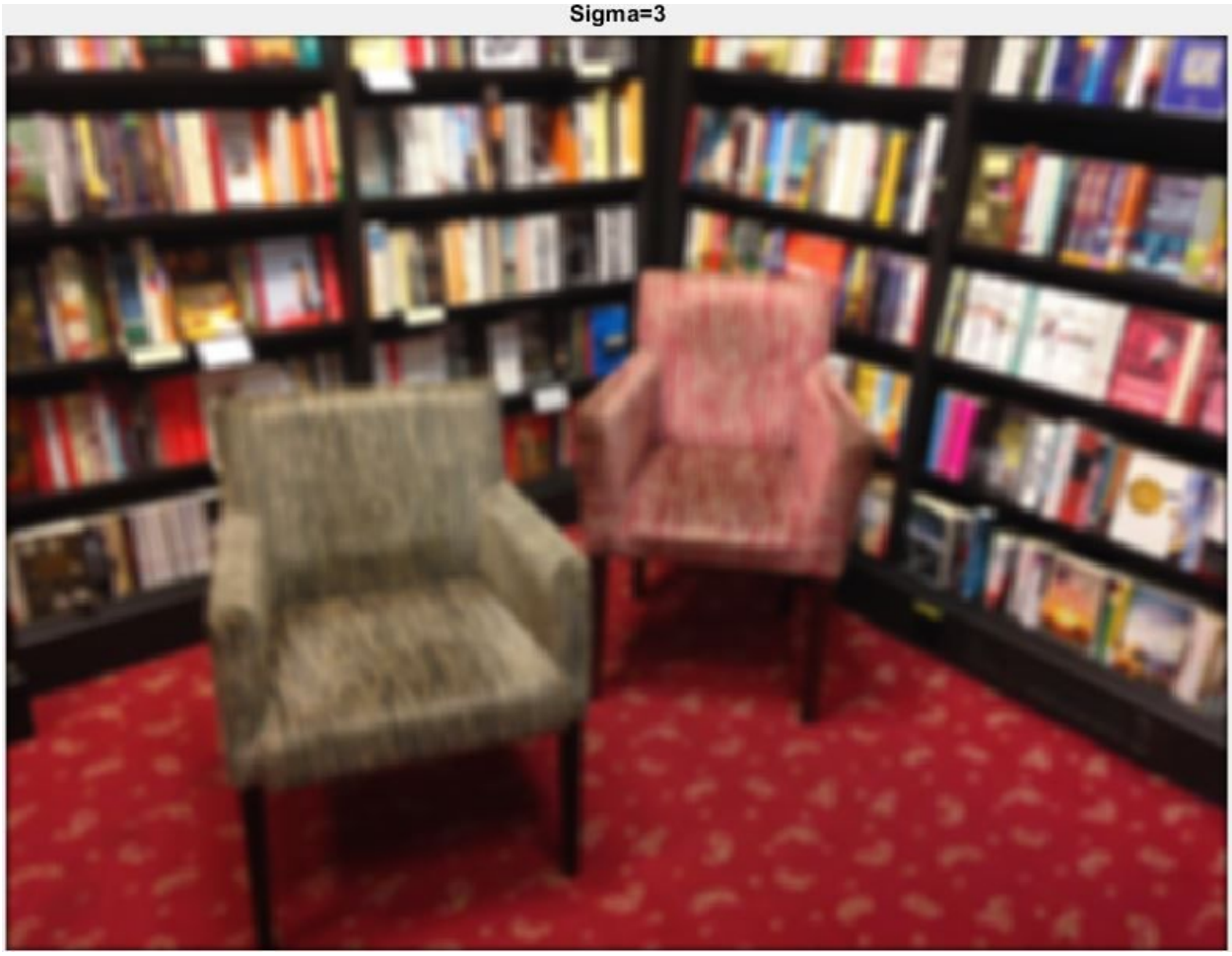
Filtered with sigma=3.



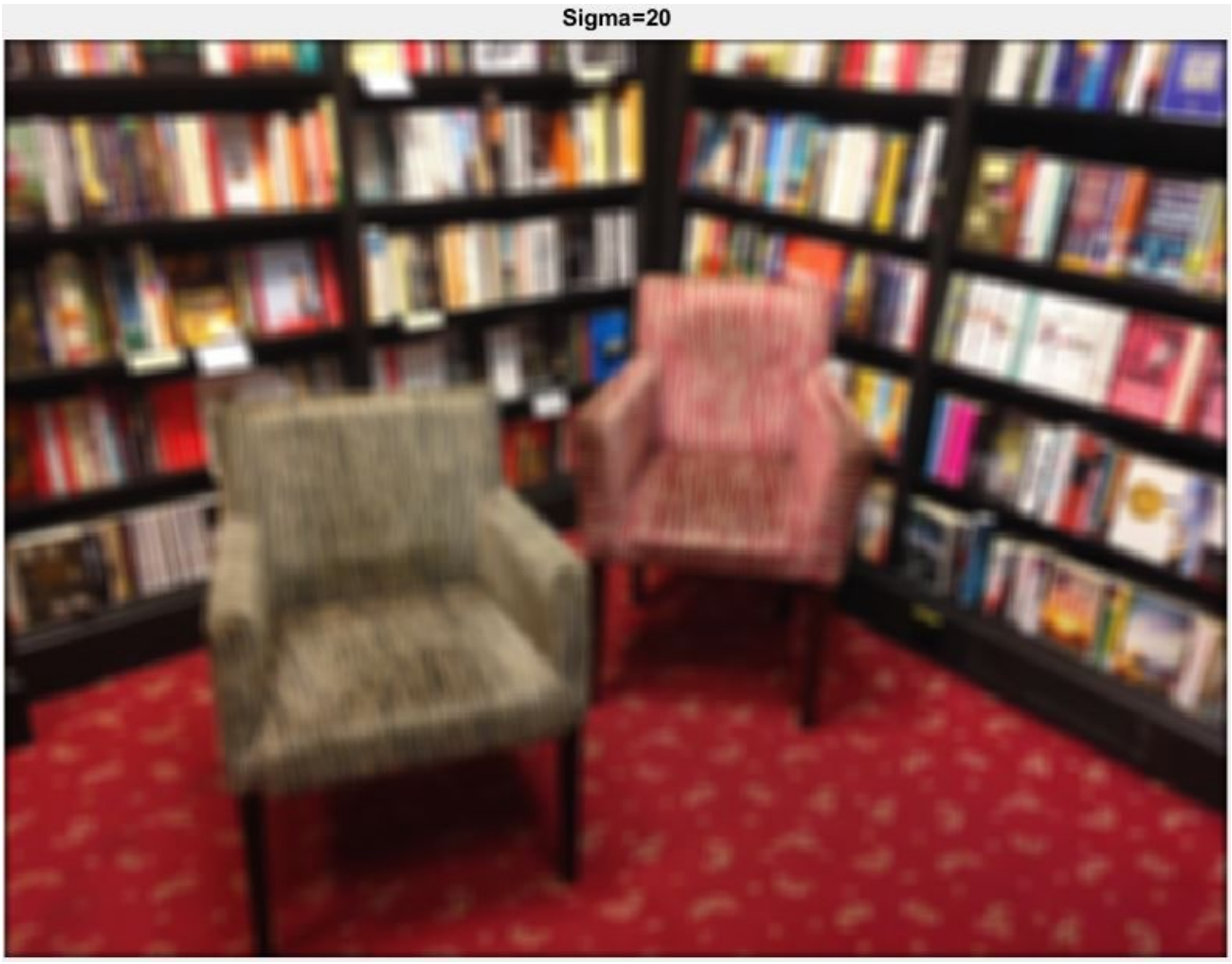
Filtered with sigma=20.

Original image

Filtered with sigma=1.



Filtered with sigma=3.



Filtered with sigma=20.

We observe that the amount of blurring (how smooth the image is) increases with increase in standard deviation of the gaussian filter.

2. (a) The Difference of Gaussian filter is created with $sigma_1 = 2.3$ and $sigma_2 = 1.5$. Its shape is similar to that of a mexican hat. The values of the kernel are:

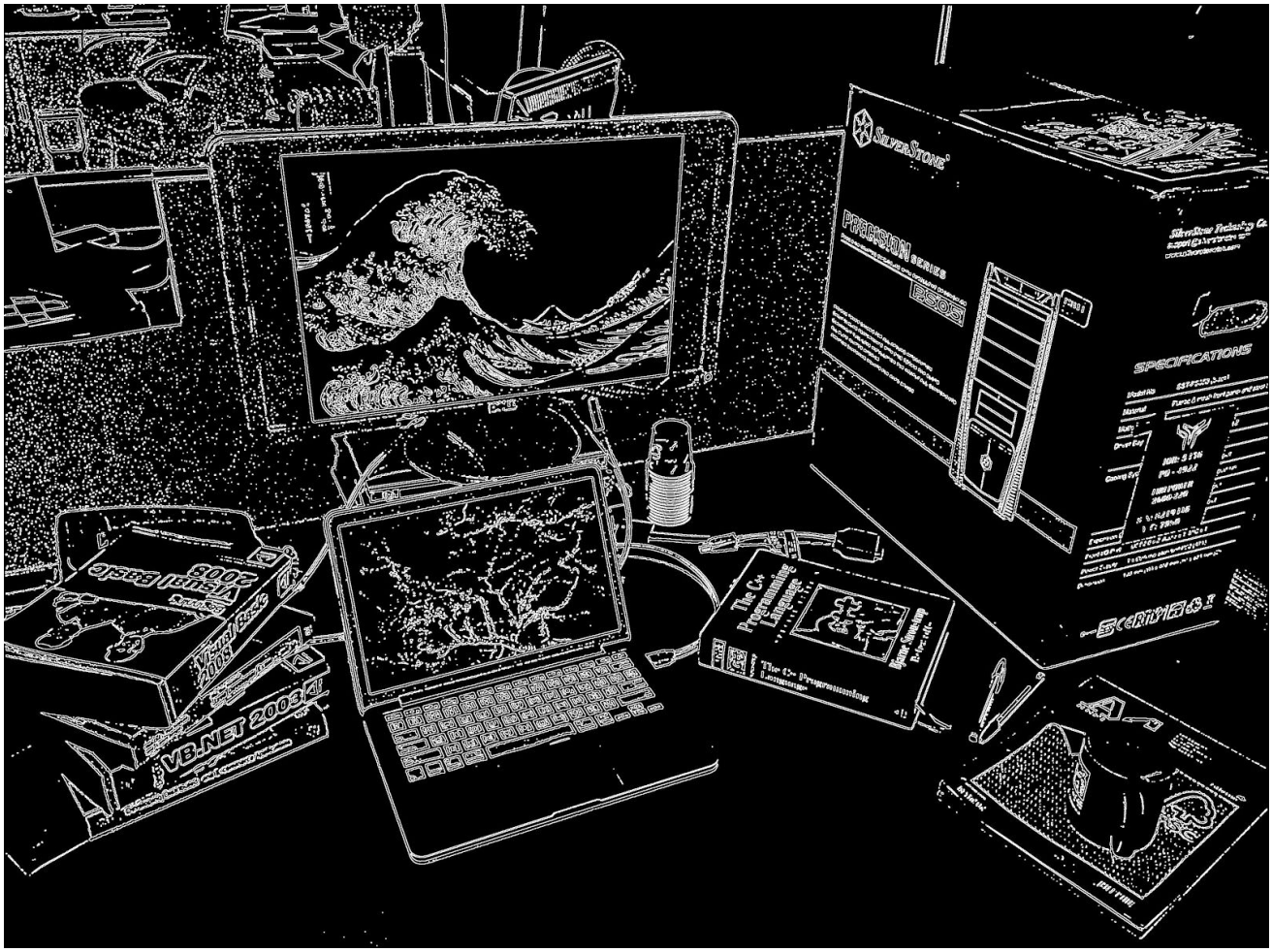
DoG filter with sigma1=2.3 and sigma2=1.5

0.0003	0.0006	0.0012	0.0018	0.0024	0.0026	0.0024	0.0018	0.0012	0.0006	0.0003
0.0006	0.0014	0.0026	0.0037	0.0044	0.0046	0.0044	0.0037	0.0026	0.0014	0.0006
0.0012	0.0026	0.0042	0.0049	0.0040	0.0033	0.0040	0.0049	0.0042	0.0026	0.0012
0.0018	0.0037	0.0049	0.0022	-0.0045	-0.0085	-0.0045	0.0022	0.0049	0.0037	0.0018
0.0024	0.0044	0.0040	-0.0045	-0.0205	-0.0293	-0.0205	-0.0045	0.0040	0.0044	0.0024
0.0026	0.0046	0.0033	-0.0085	-0.0293	-0.0406	-0.0293	-0.0085	0.0033	0.0046	0.0026
0.0024	0.0044	0.0040	-0.0045	-0.0205	-0.0293	-0.0205	-0.0045	0.0040	0.0044	0.0024
0.0018	0.0037	0.0049	0.0022	-0.0045	-0.0085	-0.0045	0.0022	0.0049	0.0037	0.0018
0.0012	0.0026	0.0042	0.0049	0.0040	0.0033	0.0040	0.0049	0.0042	0.0026	0.0012
0.0006	0.0014	0.0026	0.0037	0.0044	0.0046	0.0044	0.0037	0.0026	0.0014	0.0006
0.0003	0.0006	0.0012	0.0018	0.0024	0.0026	0.0024	0.0018	0.0012	0.0006	0.0003

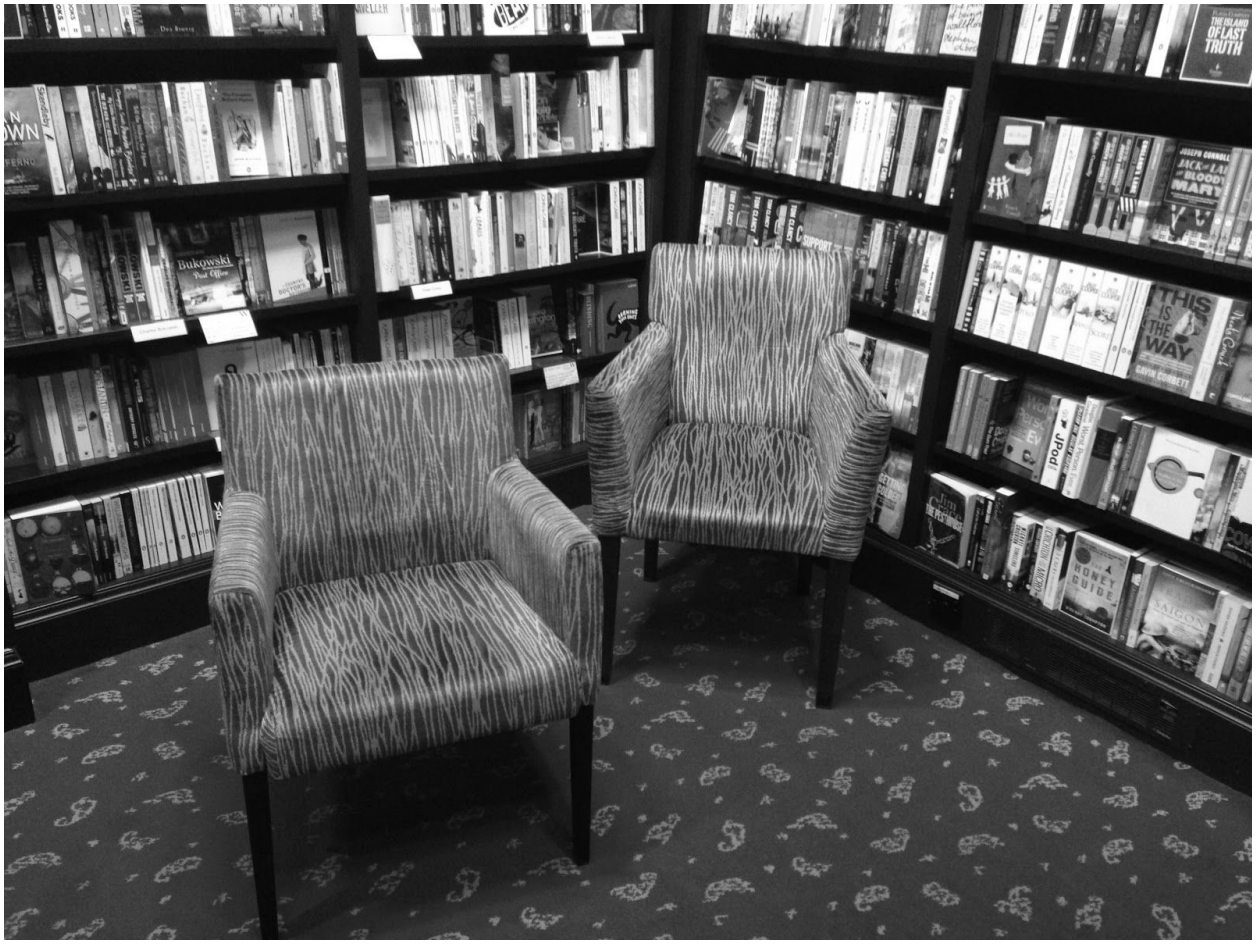
(b) The output of the filtered image can be directly seen in the MATLAB workspace. It is of double type with both negative and positive values.

(c) Now zero crossing is detected by checking 3x3 neighborhood of a given pixel and checking whether a sign change occurs. The binary image generated has pixel value 255 if certain pixel is a zero crossing else it has a pixel value of 0.

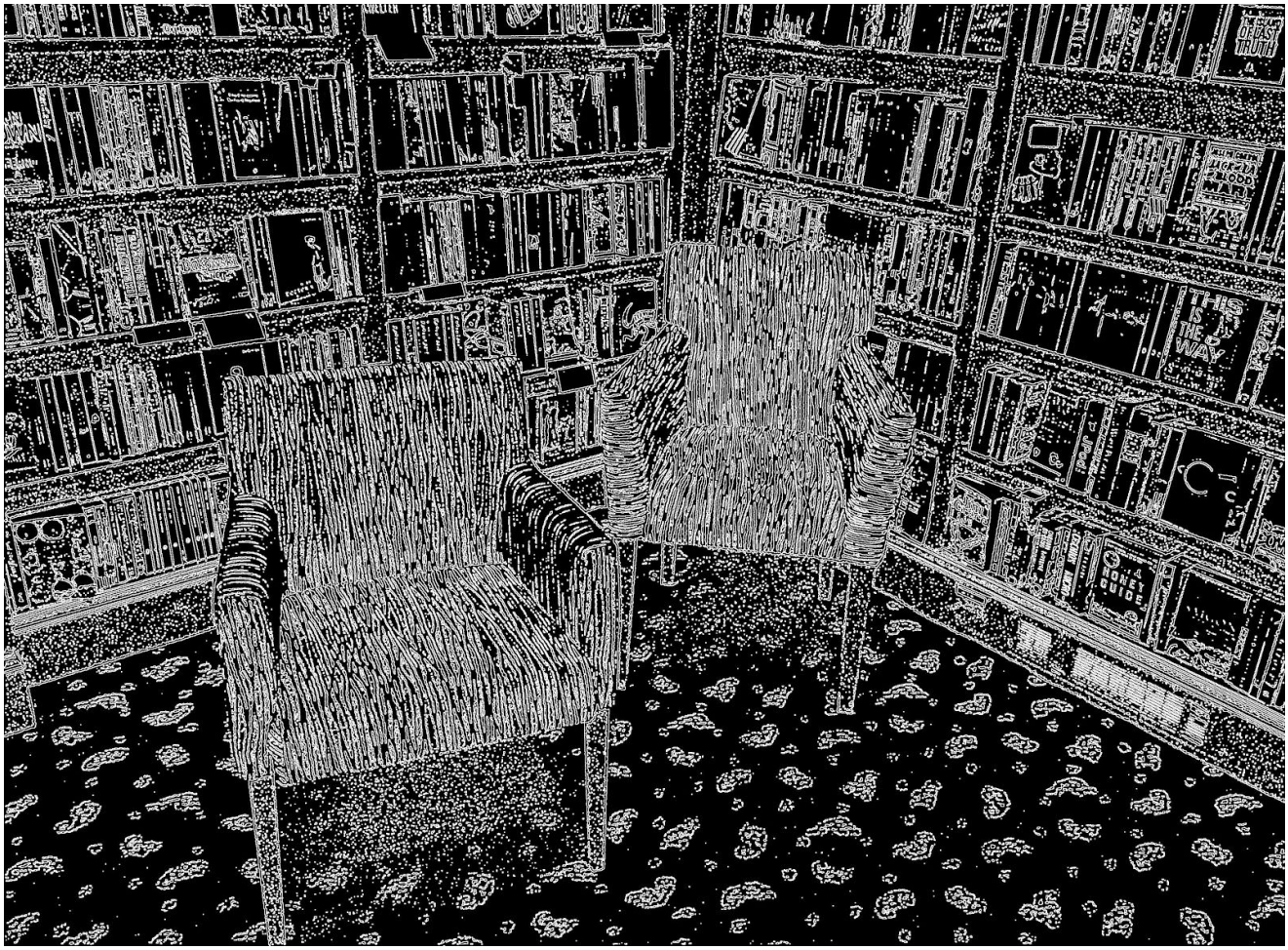
Original Image(In Grayscale)



Zero crossings of the DoG filtered image

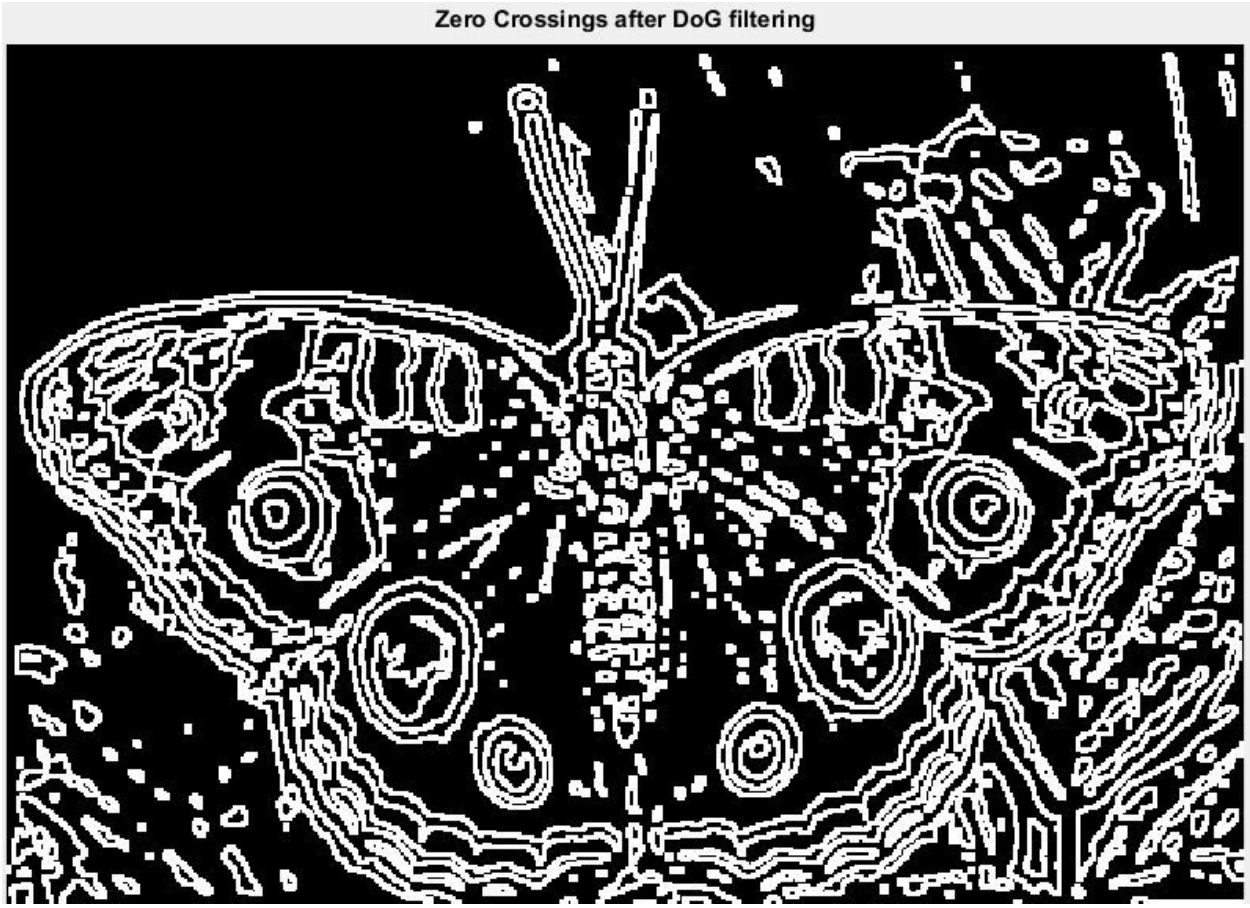


Original Image(In Grayscale)



Zero crossings of the DoG filtered image

Original Image(In Grayscale)



Zero crossings of the DoG filtered image

Zero crossings of DoG filtered image is a basic technique for edge detection.