

Image after median filtering



Part 2: Lowpass filtering and Neighborhood Averaging

1.

```
Kernel = Lowpass02;
```

2.

```
Lowpass02 = fspecial('average', 3);
```

3.

```
Lowpass5x5 = fspecial('average', 5);  
Lowpass7x7 = fspecial('average', 7);
```

4.

```
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (3x3)')
```

Low-Pass Filtered image (3x3)

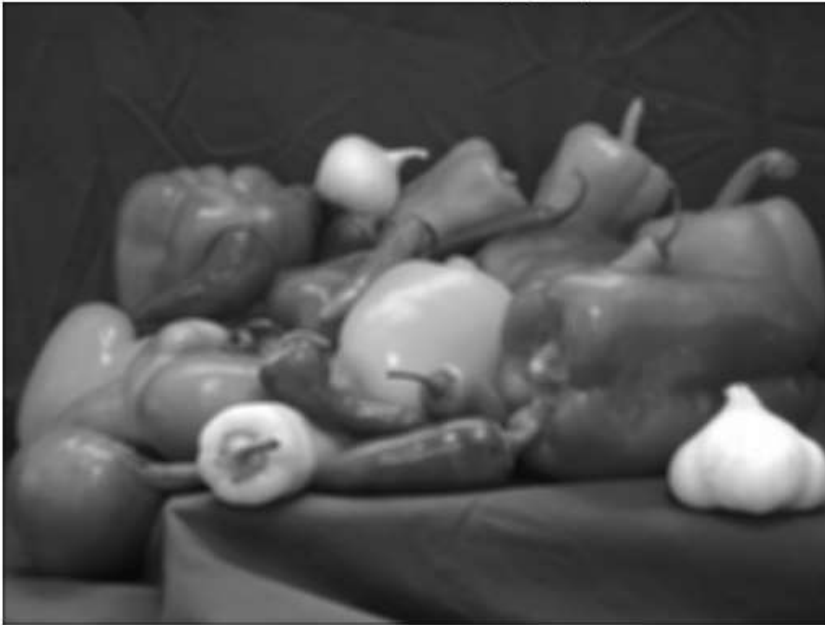


The image appears to be blurred a little bit

5.

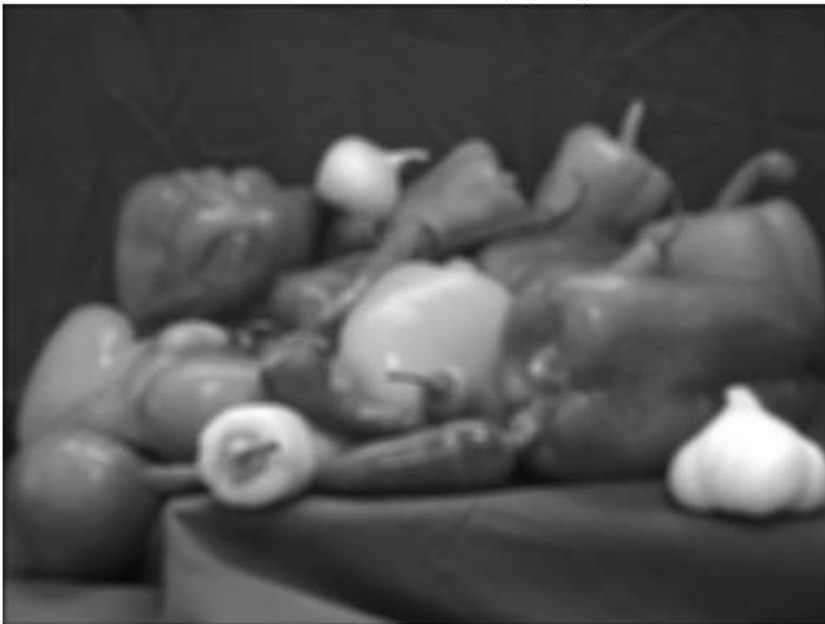
```
Kernel = Lowpass5x5;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (5x5)')
```

Low-Pass Filtered image (5x5)



```
Kernel = Lowpass7x7;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (7x7)')
```

Low-Pass Filtered image (7x7)



A larger kernel seems to blur the image more. The background looks largely unaffected.

6.

```
Iin = imnoise(Ii, 'salt & pepper', 0.02);  
imshow(Iin), title('Noisy Input image (salt & pepper)')
```

Noisy Input image (salt & pepper)



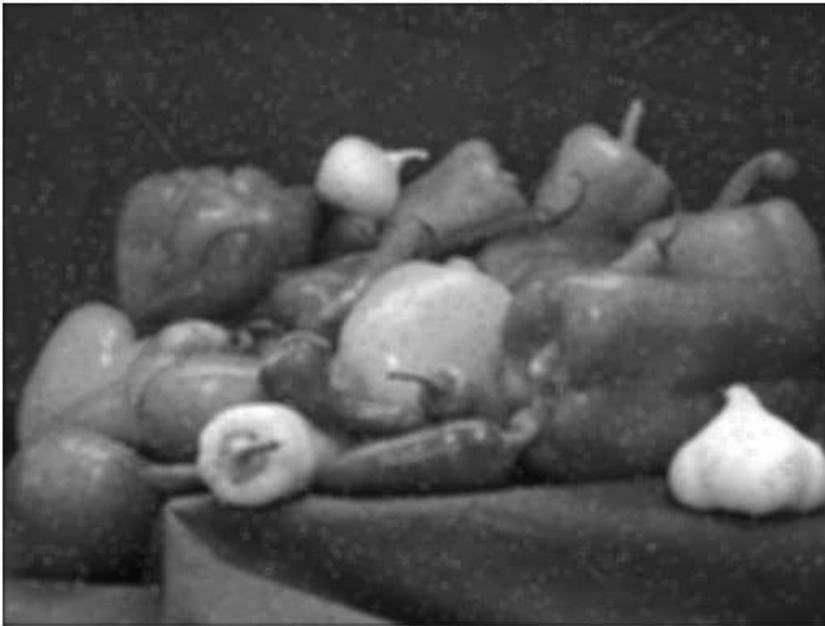
7.

```
Kernel = Lowpass02;  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (3x3)')
```



```
Kernel = Lowpass5x5;  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (5x5)')
```

Low-Pass Filtered image (5x5)



```
Kernel = Lowpass7x7;  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Io), title('Low-Pass Filtered image (7x7)')
```

Low-Pass Filtered image (7x7)



The averaging blurs both the image and the noise while the noise is still visible.

```
Kernel = Lowpass02;  
Iin = imnoise(Ii, 'gaussian', 0.02);  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Iin), title('Noisy Input image (gaussian)')
```

Noisy Input image (gaussian)



```
imshow(Io), title('Low-Pass Filtered image (3x3)')
```

Low-Pass Filtered image (3x3)



```
Kernel = Lowpass5x5;  
Iin = imnoise(Ii, 'poisson');  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Iin), title('Noisy Input image (poisson)')
```


Noisy Input image (poisson)



```
imshow(Io), title('Low-Pass Filtered image (5x5)')
```



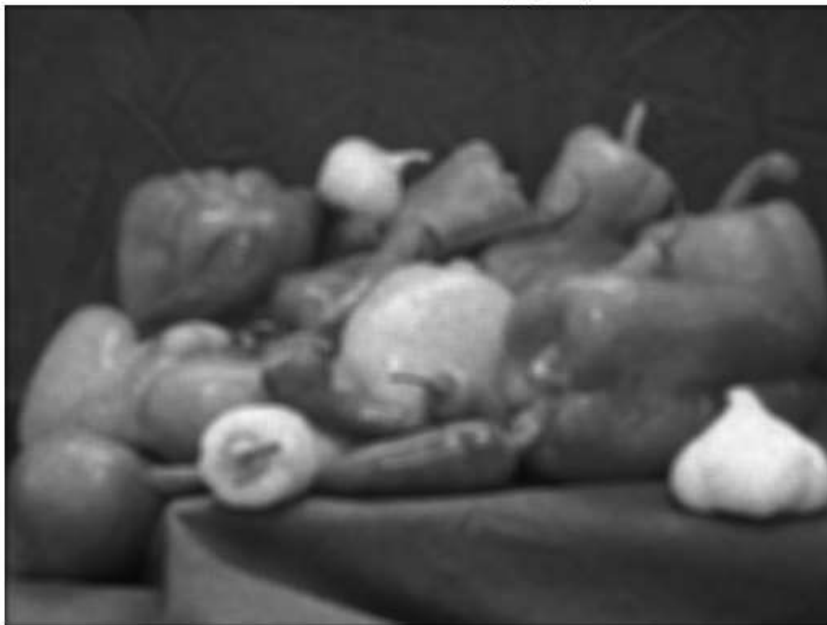
```
Kernel = Lowpass7x7;  
Iin = imnoise(Ii, 'speckle', 0.02);  
Io = imfilter(Iin, Kernel, 'conv');  
imshow(Iin), title('Noisy Input image (speckle)')
```

Noisy Input image (speckle)



```
imshow(Io), title('Low-Pass Filtered image (7x7)')
```

Low-Pass Filtered image (7x7)



The other noise functions react similarly to the filter kernel

Part 3: Noise Removal using a Median Filter

2.

```
Iin = imnoise(Ii, 'salt & pepper', 0.02);  
imshow(Iin), title('Image with "Salt and Pepper" noise')
```



```
Io = medfilt2(Iin, [3 3]);  
imshow(Io), title('Image after median filtering')
```

Image after median filtering



The median filter works very well and removes all the noise. It is much better than a lowpass filter. There is a slight side-effect of the median filter which distorts the edges of some objects. This could be the filter interpreting the edges as noise and trying to filter it.

3.

```
Iin = imnoise(Ii, 'salt & pepper', 0.1);  
imshow(Iin), title('Image with "Salt and Pepper" noise')
```

Image with "Salt and Pepper" noise



```
Io = medfilt2(Iin, [3 3]);
```

```
imshow(Io), title('Image after median filtering')
```

Image after median filtering



```
Iin = imnoise(Ii, 'salt & pepper', 0.1);  
imshow(Iin), title('Image with "Salt and Pepper" noise')
```

Image with "Salt and Pepper" noise



```
Io = medfilt2(Iin, [5 5]);  
imshow(Io), title('Image after median filtering')
```



```
Iin = imnoise(Ii, 'salt & pepper', 0.4);  
imshow(Iin), title('Image with "Salt and Pepper" noise')
```

Image with "Salt and Pepper" noise



```
Io = medfilt2(Iin, [7 7]);  
imshow(Io), title('Image after median filtering')
```

Image after median filtering



An image with too much noise cannot be completely filtered by filter that is too small. Increasing the median filter size can combat the noisiest of images but will also distort the original edges.

Part 4: Highpass Filtering

2.

```
Highpass3x3 = [ -1, -1, -1; -1, 8, -1; -1, -1, -1 ];  
Kernel = Highpass3x3;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('High-Pass Filtered image (3x3)')
```

High-Pass Filtered image (3x3)



```
Highpass5x5 = [ -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1;  
                -1, -1, 24, -1, -1;  
                -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1 ];  
Kernel = Highpass5x5;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('High-Pass Filtered image (5x5)')
```

High-Pass Filtered image (5x5)



```
Highpass7x7 = [ -1, -1, -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1, -1, -1;  
                -1, -1, -1, 48, -1, -1, -1;  
                -1, -1, -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1, -1, -1;  
                -1, -1, -1, -1, -1, -1, -1 ];  
Kernel = Highpass7x7;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('High-Pass Filtered image (7x7)')
```

High-Pass Filtered image (7x7)

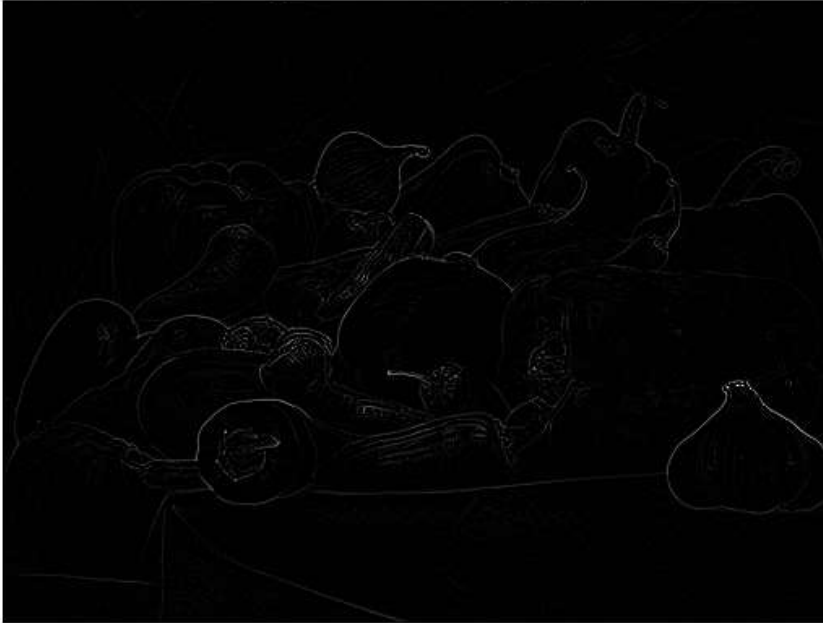


The high-pass filter accentuates the edges of the image, making them brighter and darkening the rest of the image. Increasing the kernel size looks to shift the cutoff frequency of the filter and accentuates softer edges.

3.

```
Laplacian01 = fspecial('laplacian');  
Kernel = Laplacian01;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('Laplacian Filtered image (3x3)')
```

Laplacian Filtered image (3x3)



```
S = rgb2gray(imread('cam.jpg'));  
imshow(S), title('Input image')
```

Input image



```
Io = imfilter(S, Kernel, 'conv');  
imshow(Io), title('Laplacian Filtered image (3x3)')
```

Laplacian Filtered image (3x3)



The laplacian kernel seems to be a high-pass filter with a higher cutoff frequency than normal. The image of security camera footage does not filter very well as it picks up the aliased pixels from the screen the image is taken from rather than the people in the image.

Part 5: Unsharp Masking

```
UnsharpKernel = fspecial('unsharp');  
Kernel = UnsharpKernel;  
Io = imfilter(Ii, Kernel, 'conv');  
imshow(Io), title('Unsharp Masked image')
```

Unsharp Masked image



The edges of this image seem to be more defined while not distorting the remainder of the image. A solid middle-ground between high and low pass filters.

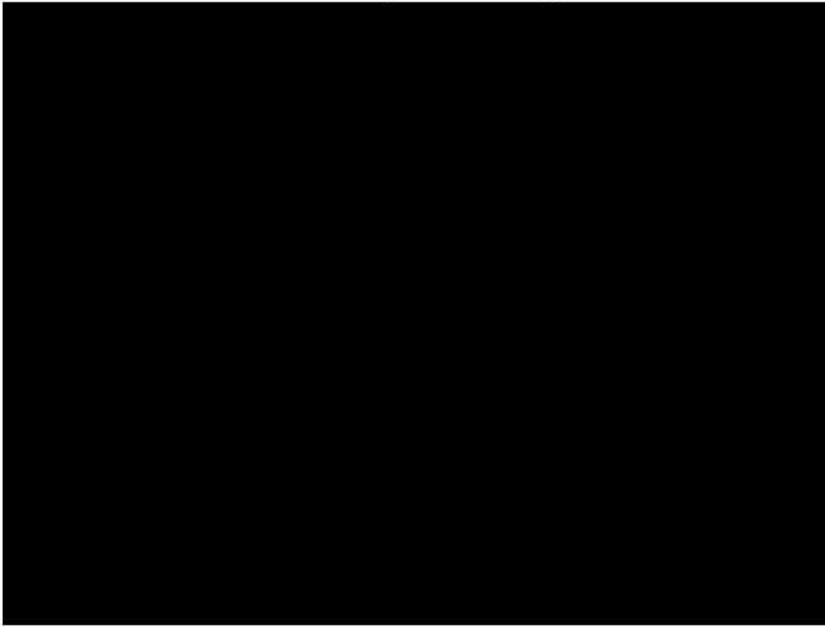
```
Kernel = Lowpass02;  
low = imfilter(Ii, Kernel, 'conv');  
imshow(low), title('Low-Pass Filtered image (3x3)')
```

Low-Pass Filtered image (3x3)



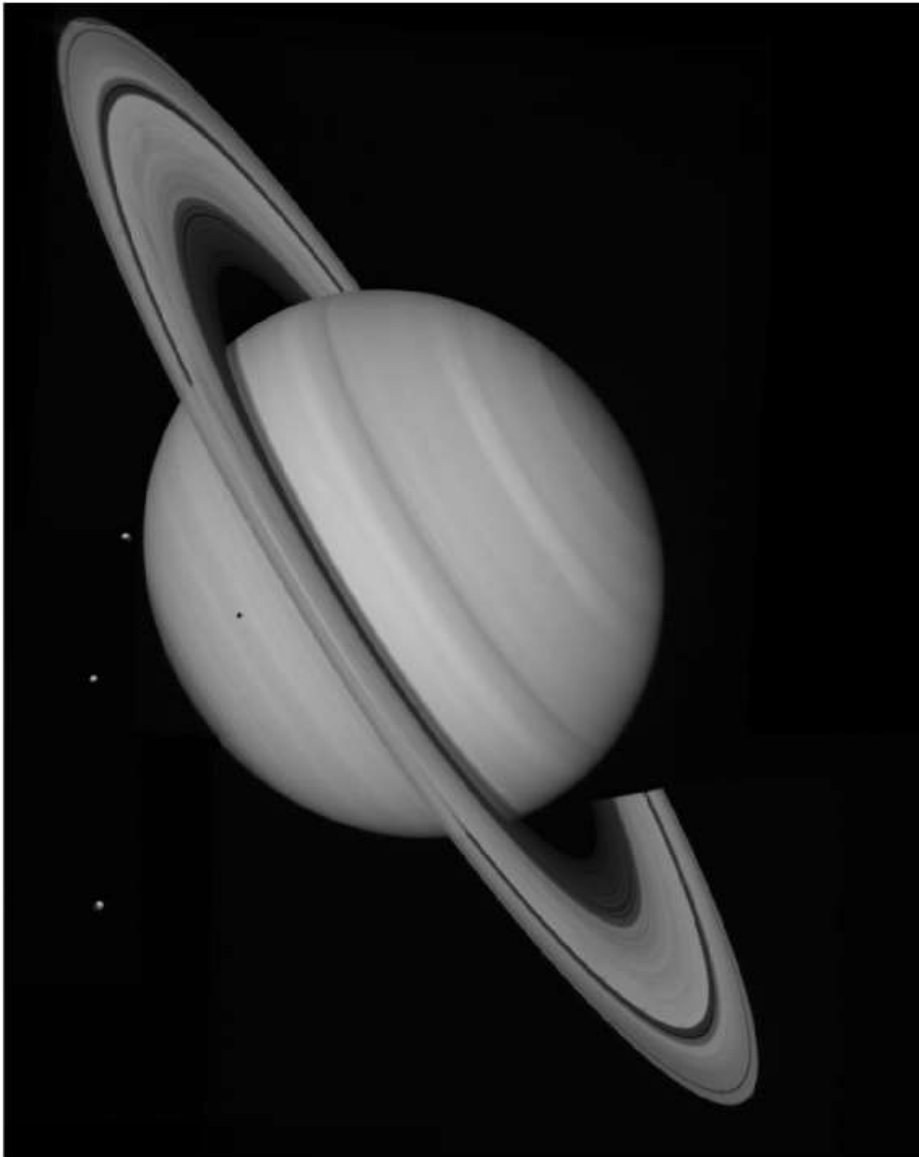
```
boost = (0.5 * Ii) - low;  
imshow(boost), title('DIY unsharp masked image')
```

DIY unsharp masked image



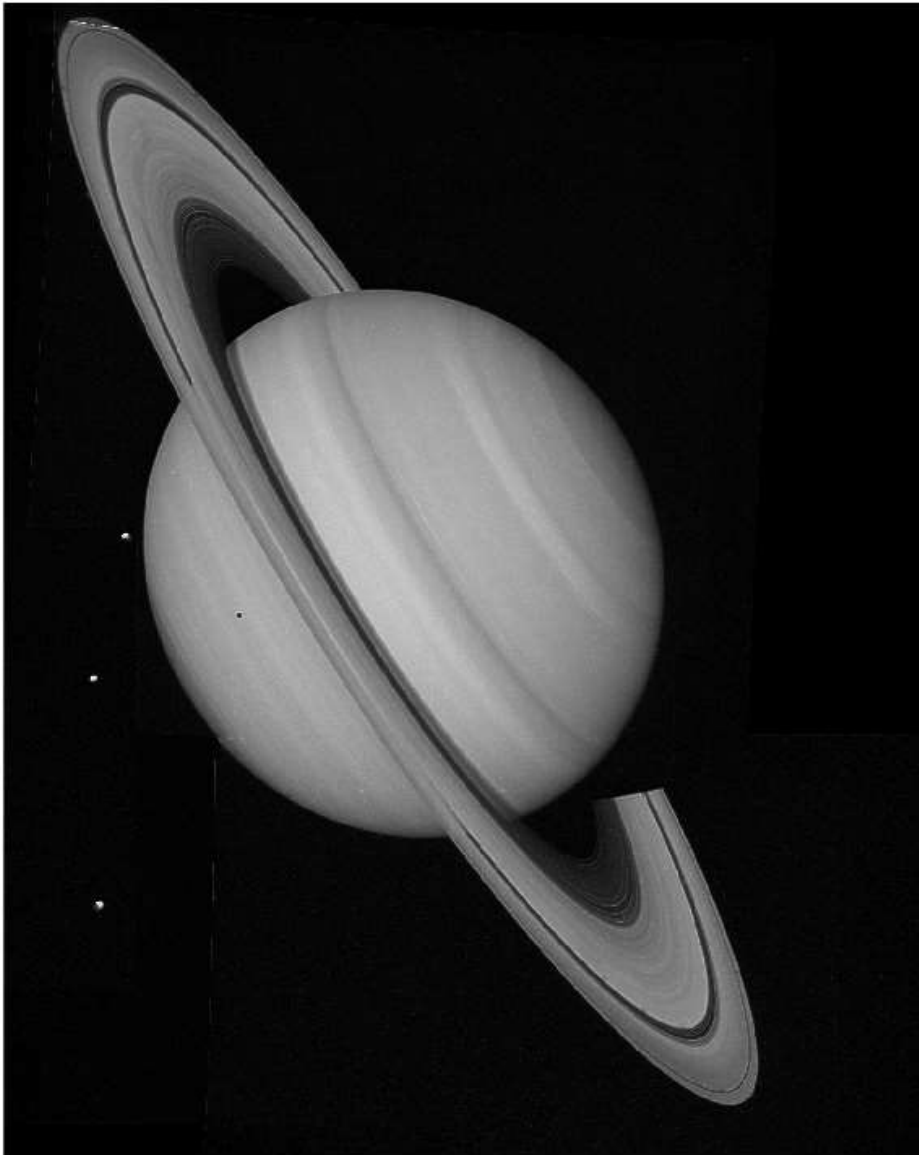
```
Iis = rgb2gray(imread('saturn.png'));  
imshow(Iis), title('Input image')
```


Input image



```
Kernel = Highpass3x3;  
Io = imfilter(Iis, Kernel, 'conv');  
imshow(Io + Iis), title('High-Pass Filtered image + original image (3x3)')
```

High-Pass Filtered image + original image (3x3)



I can't see any more moons but I can see a few rings more clearly than before. The high-pass filter could find the darker rings and superimposed that on top of the original image to boost the result.

Part 6: Edge Detection

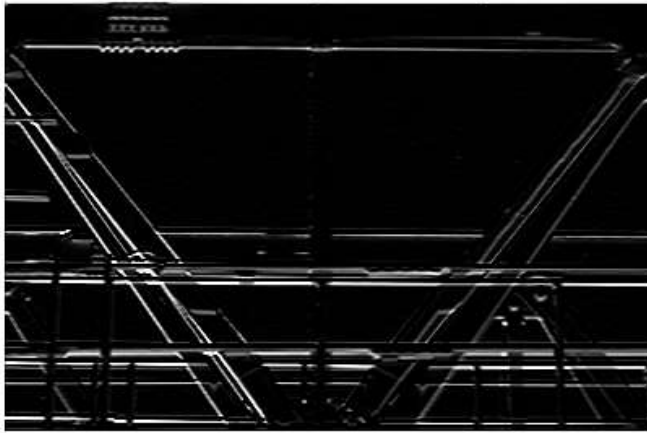
1.

```
Iig = rgb2gray(imread('gantrycrane.png'));
```

2.

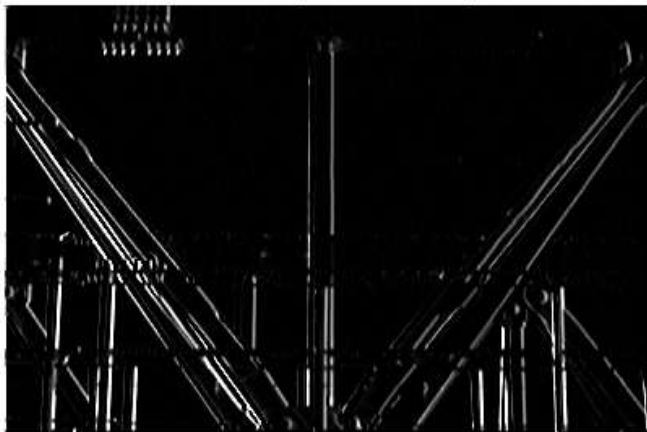
```
EdgeHorizontal01 = [ 1 1 1; 0 0 0; -1 -1 -1];  
Kernel = EdgeHorizontal01;  
Io = imfilter(Iig, Kernel, 'conv');  
imshow(Io), title('Horizontal Edge Filtered image')
```

Horizontal Edge Filtered image



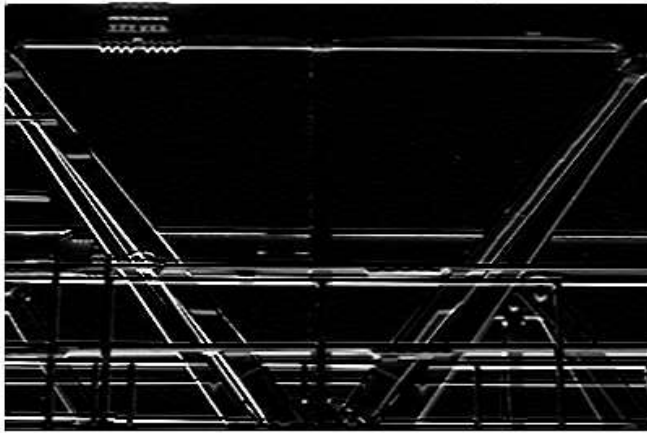
```
EdgeVertical01 = EdgeHorizontal01';  
Kernel = EdgeVertical01;  
Io = imfilter(Iig, Kernel, 'conv');  
imshow(Io), title('Vertical Edge Filtered image')
```

Vertical Edge Filtered image



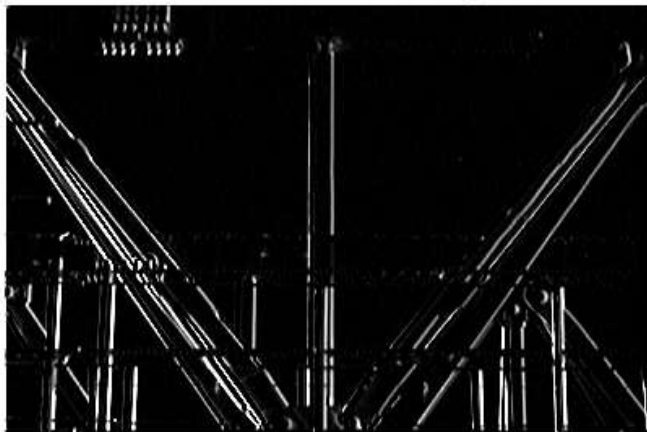
```
SobelHorizontal01 = fspecial('sobel');  
Kernel = SobelHorizontal01;  
Io = imfilter(Iig, Kernel, 'conv');  
imshow(Io), title('Sobel Horizontal Filtered image')
```

Sobel Horizontal Filtered image



```
SobelVertical01 = SobelHorizontal01';  
Kernel = SobelVertical01;  
Io = imfilter(Iig, Kernel, 'conv');  
imshow(Io), title('Sobel Vertical Filtered image')
```

Sobel Vertical Filtered image

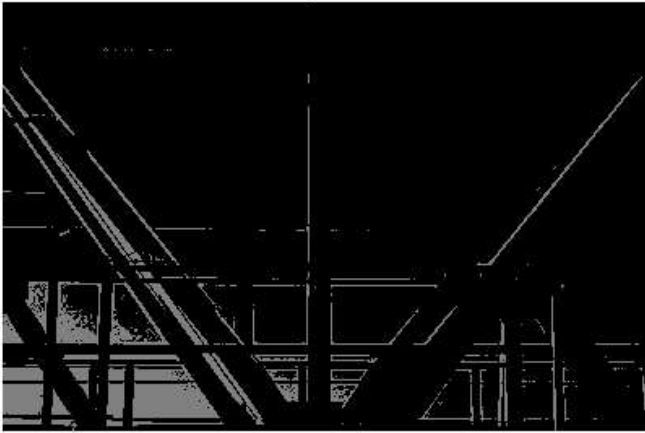


The vertical and horizontal edge filters only show vertical and horizontal edges. The sobel filters did the same for each but picked up more edges

Part 7: Bit Planes

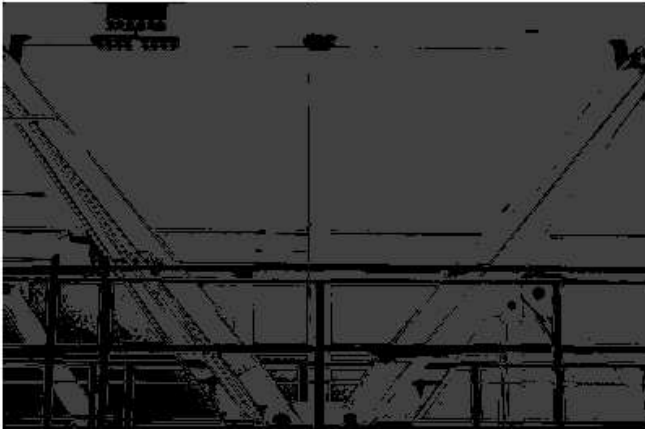
```
Ii = rgb2gray(imread('gantrycrane.png'));  
bitplane8 = Ii - mod(Ii, 128);  
bitplane7 = Ii - mod(Ii, 64) - bitplane8;  
bitplane6 = Ii - mod(Ii, 32) - bitplane8 - bitplane7;  
bitplane5 = Ii - mod(Ii, 16) - bitplane8 - bitplane7 - bitplane6;  
bitplane4 = Ii - mod(Ii, 8) - bitplane8 - bitplane7 - bitplane6 - bitplane5;  
bitplane3 = Ii - mod(Ii, 4) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4;  
bitplane2 = Ii - mod(Ii, 2) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3;  
bitplane1 = Ii - mod(Ii, 1) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3 - bitplane2;  
imshow(bitplane8), title('Bit plane 8')
```

Bit plane 8



```
imshow(bitplane7), title('Bit plane 7')
```

Bit plane 7



```
imshow(bitplane6), title('Bit plane 6')
```

Bit plane 6



```
imshow(bitplane5), title('Bit plane 5')
```

Bit plane 5



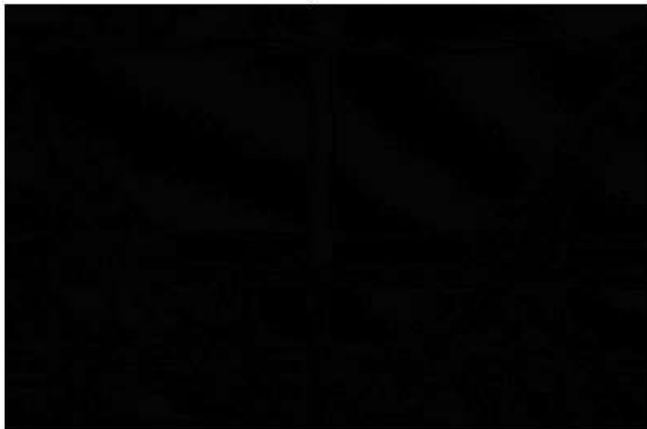
```
imshow(bitplane4), title('Bit plane 4')
```

Bit plane 4



```
imshow(bitplane3), title('Bit plane 3')
```

Bit plane 3



```
imshow(bitplane2), title('Bit plane 2')
```



```
imshow(bitplane1), title('Bit plane 1')
```

the 1990s, the number of people in the United States who are 65 years of age or older has increased by 50 percent, and the number of people 75 years of age or older has increased by 75 percent. The number of people 85 years of age or older has increased by 150 percent. The number of people 95 years of age or older has increased by 300 percent. The number of people 100 years of age or older has increased by 500 percent. The number of people 105 years of age or older has increased by 1,000 percent. The number of people 110 years of age or older has increased by 2,000 percent. The number of people 115 years of age or older has increased by 4,000 percent. The number of people 120 years of age or older has increased by 8,000 percent. The number of people 125 years of age or older has increased by 16,000 percent. The number of people 130 years of age or older has increased by 32,000 percent. The number of people 135 years of age or older has increased by 64,000 percent. The number of people 140 years of age or older has increased by 128,000 percent. The number of people 145 years of age or older has increased by 256,000 percent. The number of people 150 years of age or older has increased by 512,000 percent. The number of people 155 years of age or older has increased by 1,024,000 percent. The number of people 160 years of age or older has increased by 2,048,000 percent. The number of people 165 years of age or older has increased by 4,096,000 percent. The number of people 170 years of age or older has increased by 8,192,000 percent. The number of people 175 years of age or older has increased by 16,384,000 percent. The number of people 180 years of age or older has increased by 32,768,000 percent. The number of people 185 years of age or older has increased by 65,536,000 percent. The number of people 190 years of age or older has increased by 131,072,000 percent. The number of people 195 years of age or older has increased by 262,144,000 percent. The number of people 200 years of age or older has increased by 524,288,000 percent. The number of people 205 years of age or older has increased by 1,048,576,000 percent. The number of people 210 years of age or older has increased by 2,097,152,000 percent. The number of people 215 years of age or older has increased by 4,194,304,000 percent. The number of people 220 years of age or older has increased by 8,388,608,000 percent. The number of people 225 years of age or older has increased by 16,777,216,000 percent. The number of people 230 years of age or older has increased by 33,554,432,000 percent. The number of people 235 years of age or older has increased by 67,108,864,000 percent. The number of people 240 years of age or older has increased by 134,217,728,000 percent. The number of people 245 years of age or older has increased by 268,435,456,000 percent. The number of people 250 years of age or older has increased by 536,870,912,000 percent. The number of people 255 years of age or older has increased by 1,073,741,824,000 percent. The number of people 260 years of age or older has increased by 2,147,483,648,000 percent. The number of people 265 years of age or older has increased by 4,294,967,296,000 percent. The number of people 270 years of age or older has increased by 8,589,934,592,000 percent. The number of people 275 years of age or older has increased by 17,179,869,184,000 percent. The number of people 280 years of age or older has increased by 34,359,738,368,000 percent. The number of people 285 years of age or older has increased by 68,719,476,736,000 percent. The number of people 290 years of age or older has increased by 137,438,953,472,000 percent. The number of people 295 years of age or older has increased by 274,877,906,944,000 percent. The number of people 300 years of age or older has increased by 549,755,813,888,000 percent. The number of people 305 years of age or older has increased by 1,099,511,627,776,000 percent. The number of people 310 years of age or older has increased by 2,199,023,255,552,000 percent. The number of people 315 years of age or older has increased by 4,398,046,511,104,000 percent. The number of people 320 years of age or older has increased by 8,796,093,022,208,000 percent. The number of people 325 years of age or older has increased by 17,592,186,044,416,000 percent. The number of people 330 years of age or older has increased by 35,184,372,088,832,000 percent. The number of people 335 years of age or older has increased by 70,368,744,177,664,000 percent. The number of people 340 years of age or older has increased by 140,737,488,355,328,000 percent. The number of people 345 years of age or older has increased by 281,474,976,710,656,000 percent. The number of people 350 years of age or older has increased by 562,949,953,421,312,000 percent. The number of people 355 years of age or older has increased by 1,125,899,906,842,624,000 percent. The number of people 360 years of age or older has increased by 2,251,799,813,685,248,000 percent. The number of people 365 years of age or older has increased by 4,503,599,627,370,496,000 percent. The number of people 370 years of age or older has increased by 9,007,199,254,740,992,000 percent. The number of people 375 years of age or older has increased by 18,014,398,509,481,984,000 percent. The number of people 380 years of age or older has increased by 36,028,797,018,963,968,000 percent. The number of people 385 years of age or older has increased by 72,057,594,037,927,936,000 percent. The number of people 390 years of age or older has increased by 144,115,188,075,855,872,000 percent. The number of people 395 years of age or older has increased by 288,230,376,151,711,744,000 percent. The number of people 400 years of age or older has increased by 576,460,752,303,423,488,000 percent. The number of people 405 years of age or older has increased by 1,152,921,504,606,846,976,000 percent. The number of people 410 years of age or older has increased by 2,305,843,009,213,693,952,000 percent. The number of people 415 years of age or older has increased by 4,611,686,018,427,387,904,000 percent. The number of people 420 years of age or older has increased by 9,223,372,036,854,775,808,000 percent. The number of people 425 years of age or older has increased by 18,446,744,073,709,551,616,000 percent. The number of people 430 years of age or older has increased by 36,893,488,147,419,103,232,000 percent. The number of people 435 years of age or older has increased by 73,786,976,294,838,206,464,000 percent. The number of people 440 years of age or older has increased by 147,573,952,589,676,412,928,000 percent. The number of people 445 years of age or older has increased by 295,147,905,179,352,825,856,000 percent. The number of people 450 years of age or older has increased by 590,295,810,358,705,651,712,000 percent. The number of people 455 years of age or older has increased by 1,180,591,620,717,411,303,424,000 percent. The number of people 460 years of age or older has increased by 2,361,183,241,434,822,606,848,000 percent. The number of people 465 years of age or older has increased by 4,722,366,482,869,645,213,696,000 percent. The number of people 470 years of age or older has increased by 9,444,732,965,739,290,427,392,000 percent. The number of people 475 years of age or older has increased by 18,889,465,931,478,580,854,784,000 percent. The number of people 480 years of age or older has increased by 37,778,931,862,957,161,709,568,000 percent. The number of people 485 years of age or older has increased by 75,557,863,725,914,323,419,136,000 percent. The number of people 490 years of age or older has increased by 151,115,727,451,828,646,838,272,000 percent. The number of people 495 years of age or older has increased by 302,231,454,903,657,293,676,544,000 percent. The number of people 500 years of age or older has increased by 604,462,909,807,314,587,353,088,000 percent. The number of people 505 years of age or older has increased by 1,208,925,819,614,629,174,706,176,000 percent. The number of people 510 years of age or older has increased by 2,417,851,639,229,258,349,412,352,000 percent. The number of people 515 years of age or older has increased by 4,835,703,278,458,516,698,824,704,000 percent. The number of people 520 years of age or older has increased by 9,671,406,556,917,033,397,649,408,000 percent. The number of people 525 years of age or older has increased by 19,342,813,113,834,066,795,298,816,000 percent. The number of people 530 years of age or older has increased by 38,685,626,227,668,133,590,597,632,000 percent. The number of people 535 years of age or older has increased by 77,371,252,455,336,267,181,195,264,000 percent. The number of people 540 years of age or older has increased by 154,742,504,910,672,534,362,390,528,000 percent. The number of people 545 years of age or older has increased by 309,485,009,821,345,068,724,781,056,000 percent. The number of people 550 years of age or older has increased by 618,970,019,642,690,137,449,562,112,000 percent. The number of people 555 years of age or older has increased by 1,237,940,039,285,380,274,899,124,224,000 percent. The number of people 560 years of age or older has increased by 2,475,880,078,570,760,549,798,248,448,000 percent. The number of people 565 years of age or older has increased by 4,951,760,157,141,521,099,596,496,896,000 percent. The number of people 570 years of age or older has increased by 9,903,520,314,283,042,199,193,993,792,000 percent. The number of people 575 years of age or older has increased by 19,807,040

```
recombine = bitplane8 + bitplane7 + bitplane6 + bitplane5 + bitplane4 + bitplane3 + bitplane2 + bitplane1;
a = Ii - recombine
```

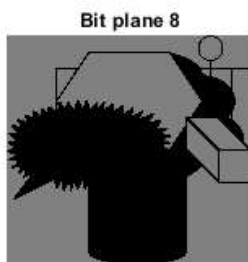
[illegible]

```
imshow(recombine)
```

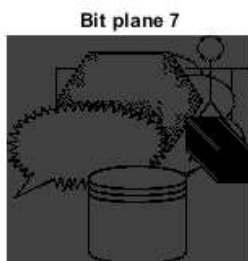


There are no differences after recombining the bit planes.

```
Ii = rgb2gray(imread('syn.jpg'));
bitplane8 = Ii - mod(Ii, 128);
bitplane7 = Ii - mod(Ii, 64) - bitplane8;
bitplane6 = Ii - mod(Ii, 32) - bitplane8 - bitplane7;
bitplane5 = Ii - mod(Ii, 16) - bitplane8 - bitplane7 - bitplane6;
bitplane4 = Ii - mod(Ii, 8) - bitplane8 - bitplane7 - bitplane6 - bitplane5;
bitplane3 = Ii - mod(Ii, 4) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4;
bitplane2 = Ii - mod(Ii, 2) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3;
bitplane1 = Ii - mod(Ii, 1) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3 - bitplane2;
imshow(bitplane8), title('Bit plane 8')
```



```
imshow(bitplane7), title('Bit plane 7')
```



```
imshow(bitplane6), title('Bit plane 6')
```


Bit plane 6



```
imshow(bitplane5), title('Bit plane 5')
```

Bit plane 5



```
imshow(bitplane4), title('Bit plane 4')
```

Bit plane 4



```
imshow(bitplane3), title('Bit plane 3')
```

Bit plane 3



```
imshow(bitplane2), title('Bit plane 2')
```

Bit plane 2



```
imshow(bitplane1), title('Bit plane 1')
```

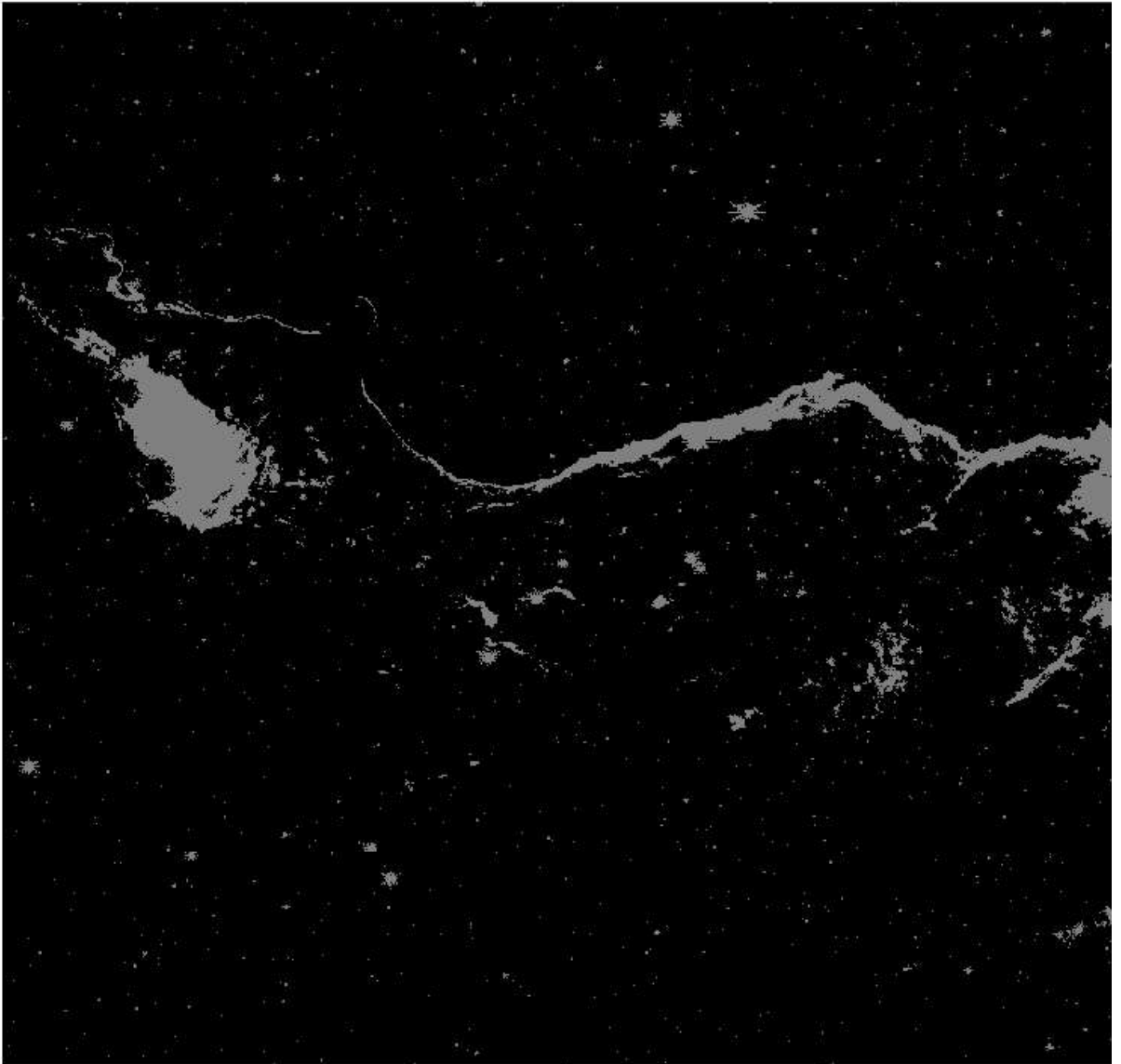
Bit plane 1



The images for each bit plane are what I expect

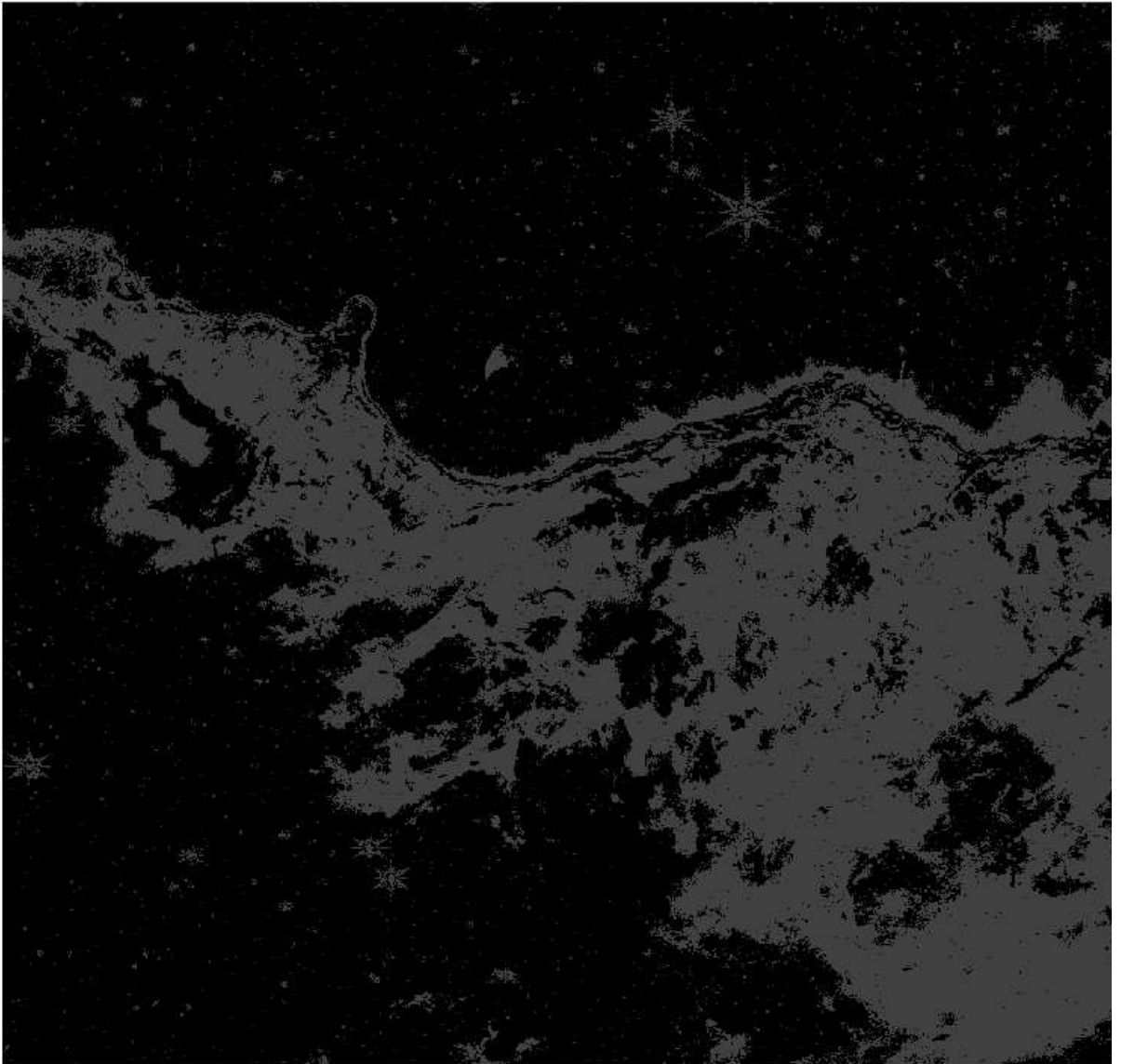
```
Ii = rgb2gray(imread('space.png'));
bitplane8 = Ii - mod(Ii, 128);
bitplane7 = Ii - mod(Ii, 64) - bitplane8;
bitplane6 = Ii - mod(Ii, 32) - bitplane8 - bitplane7;
bitplane5 = Ii - mod(Ii, 16) - bitplane8 - bitplane7 - bitplane6;
bitplane4 = Ii - mod(Ii, 8) - bitplane8 - bitplane7 - bitplane6 - bitplane5;
bitplane3 = Ii - mod(Ii, 4) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4;
bitplane2 = Ii - mod(Ii, 2) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3;
bitplane1 = Ii - mod(Ii, 1) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3 - bitplane2;
imshow(bitplane8), title('Bit plane 8')
```

Bit plane 8



```
imshow(bitplane7), title('Bit plane 7')
```

Bit plane 7



```
imshow(bitplane6), title('Bit plane 6')
```

Bit plane 6



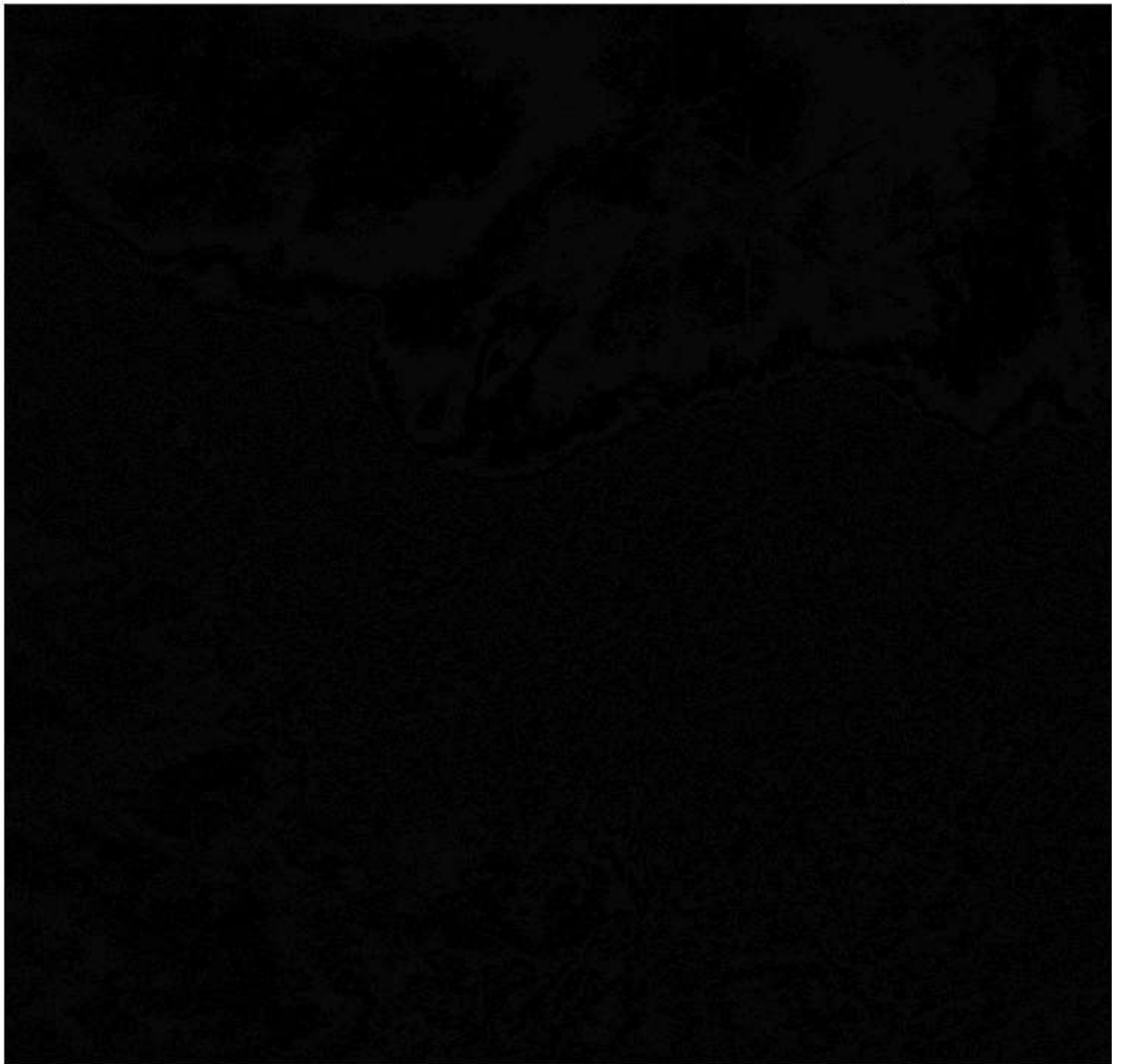
```
imshow(bitplane5), title('Bit plane 5')
```

Bit plane 5



```
imshow(bitplane4), title('Bit plane 4')
```

Bit plane 4



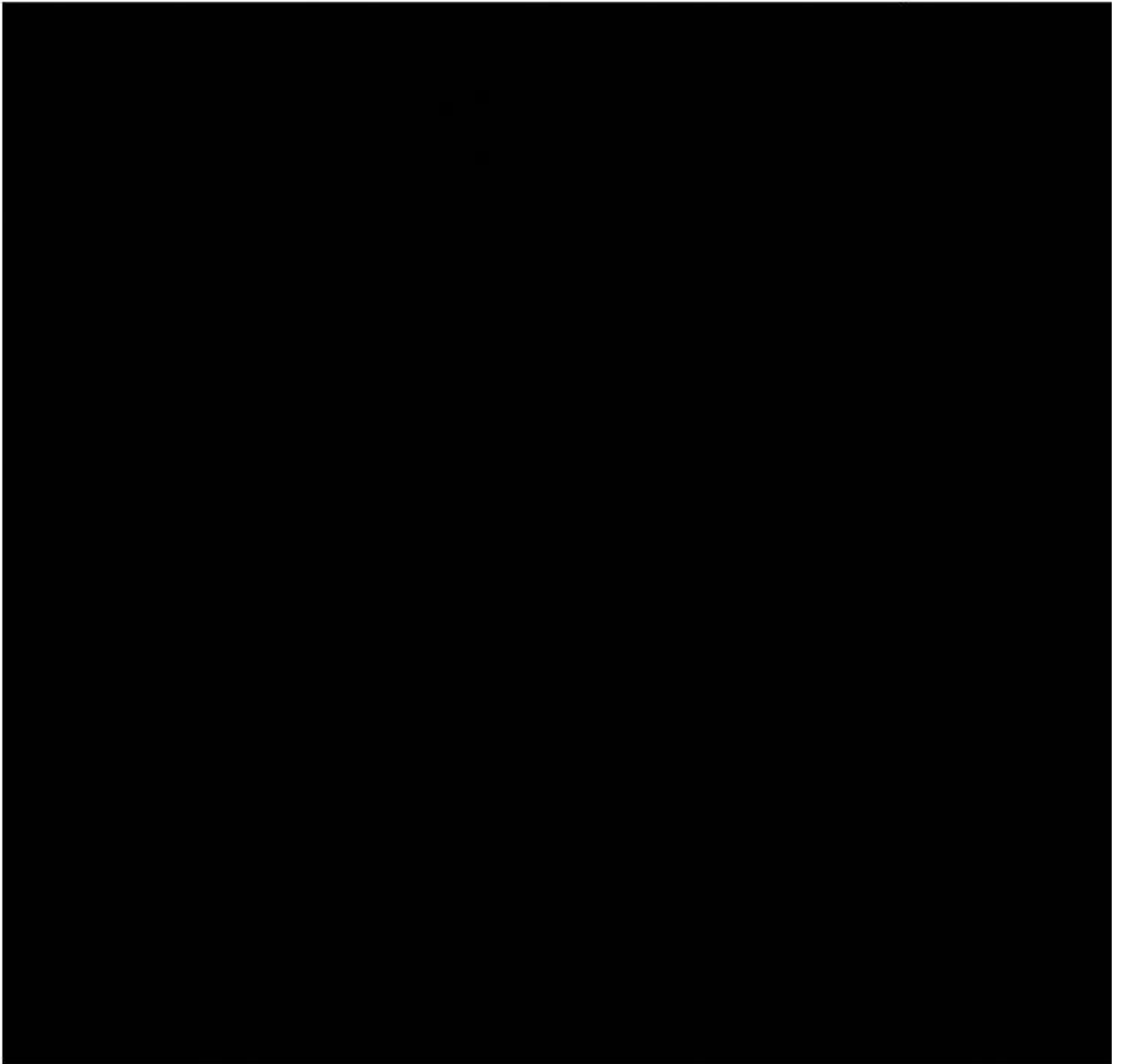
```
imshow(bitplane3), title('Bit plane 3')
```

Bit plane 3



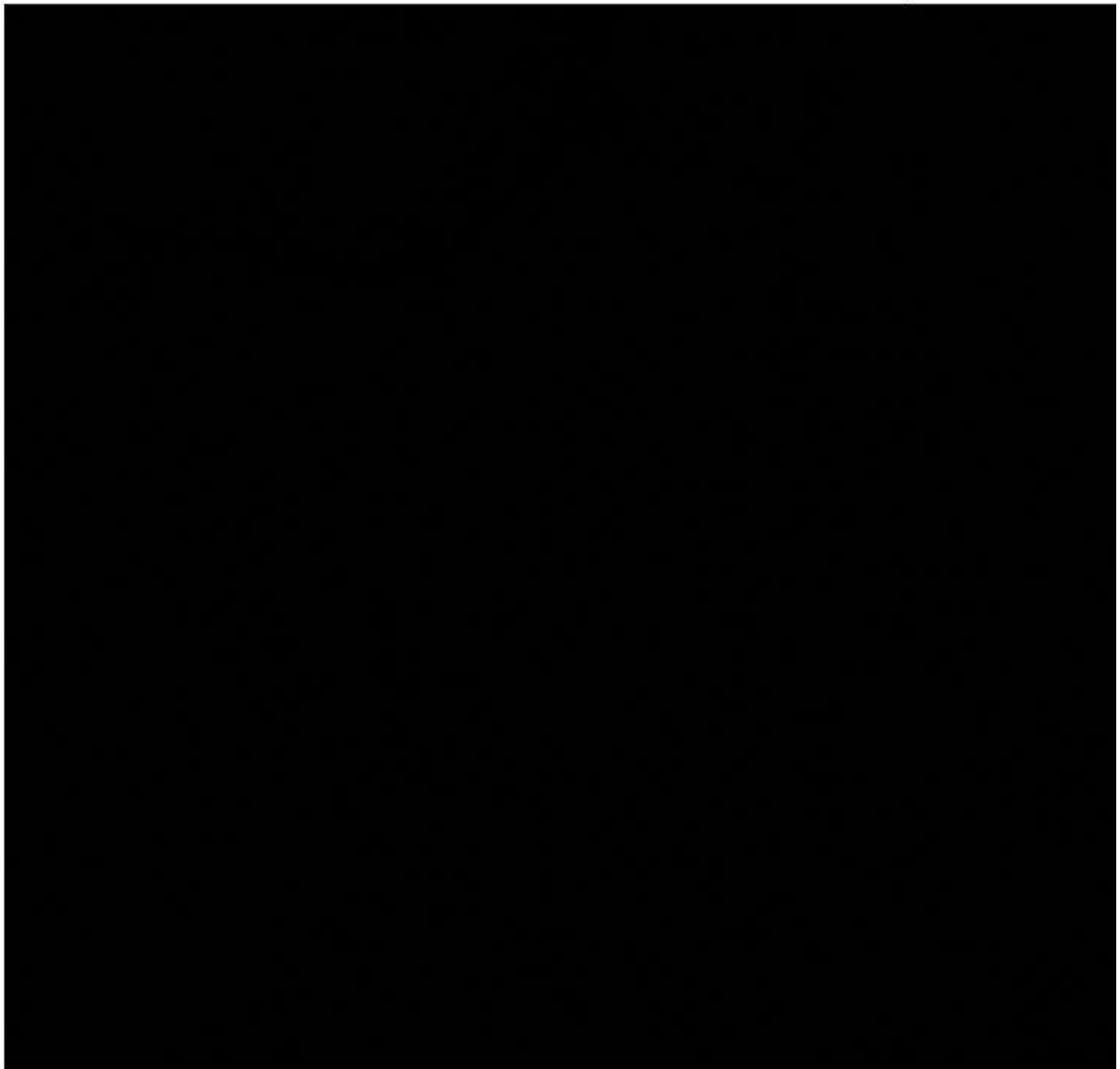
```
imshow(bitplane2), title('Bit plane 2')
```


Bit plane 2



```
imshow(bitplane1), title('Bit plane 1')
```

Bit plane 1



The images for each bit plane are what I expect

```
Ii = imread('mycameraman2.png');
bitplane8 = Ii - mod(Ii, 128);
bitplane7 = Ii - mod(Ii, 64) - bitplane8;
bitplane6 = Ii - mod(Ii, 32) - bitplane8 - bitplane7;
bitplane5 = Ii - mod(Ii, 16) - bitplane8 - bitplane7 - bitplane6;
bitplane4 = Ii - mod(Ii, 8) - bitplane8 - bitplane7 - bitplane6 - bitplane5;
bitplane3 = Ii - mod(Ii, 4) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4;
bitplane2 = Ii - mod(Ii, 2) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3;
bitplane1 = Ii - mod(Ii, 1) - bitplane8 - bitplane7 - bitplane6 - bitplane5 - bitplane4 - bitplane3 - bitplane2;
imshow(bitplane8), title('Bit plane 8')
```

Bit plane 8



```
imshow(bitplane7), title('Bit plane 7')
```

Bit plane 7



```
imshow(bitplane6), title('Bit plane 6')
```

Bit plane 6



```
imshow(bitplane5), title('Bit plane 5')
```

Bit plane 5



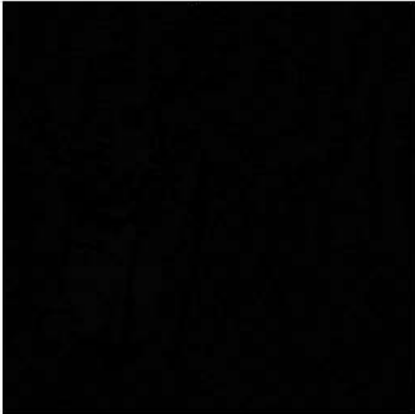
```
imshow(bitplane4), title('Bit plane 4')
```

Bit plane 4



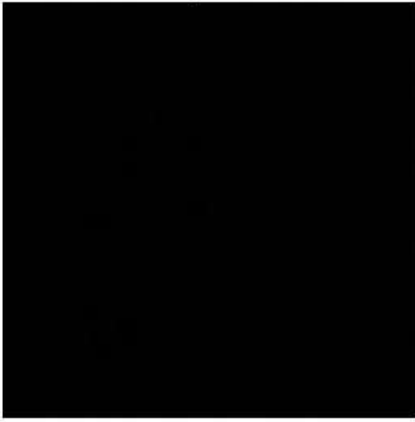
```
imshow(bitplane3), title('Bit plane 3')
```

Bit plane 3



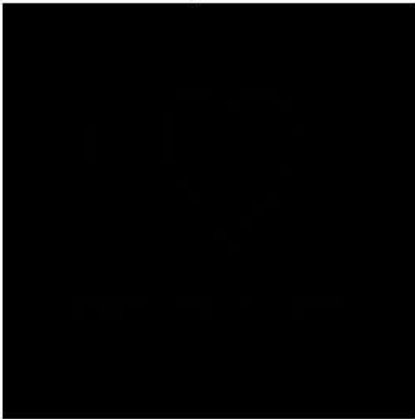
```
imshow(bitplane2), title('Bit plane 2')
```

Bit plane 2



```
imshow(bitplane1), title('Bit plane 1')
```

Bit plane 1



The images for each bit plane are what I expect. The cameraman appears to be taking a picture