

Image Processing 2

I have adhered to the Duke Community Standard in completing this assignment.

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1 Exercises 1 and 2

For exercise 1, the analysis function created was tested and the expected output in example 2 of the laboratory manual was obtained. For exercise 2, both the trigonometric and exponential synthesis functions created were tested using the outputs of the analysis function; both synthesis functions gave the input to the analysis function as output.

2 Exercise 3

As shown in the figures attached for this exercise, decreasing the radius of the LPF filter increases the intensity of the blur applied to the coins image. Increasing the radius of the LPF filter decreases the intensity of the blur. As the radius is decreased from 0.5 to 0.1, the blur effect on the image output increases.

3 Exercise 4

Similar to the results in exercise 4, decreasing the radius of the LPF filter increases the intensity of the blur applied to the coins image. Increasing the radius of the LPF filter decreases the intensity of the blur. As the radius is decreased from 0.5 to 0.1, the blur effect on the image output increases and distinguishing the darkness of the dots gets increasingly difficult.

4 Exercise 5

The image changes in pattern every time the code is run. The image shows sections that are concentrated with white and other sections with higher concentrated darkness. The surface shows a 3-D surface plot of the image where the brighter the region is in the image the higher it is on the z-axis of the surface.

5 Exercise 6

As the limit of the $\text{abs}(u)$ decreases (i.e. the height of the rectangular LPF filter decreases) vertical blurring in the image increases. As the limit of the $\text{abs}(v)$ decreases (i.e. the width of the rectangular LPF filter decreases) horizontal blurring in the image increases.

6 Exercise 7

Similar to exercise 6, as the limit of the $\text{abs}(u)$ decreases vertical blurring in the image increases. As the limit of the $\text{abs}(v)$ decreases (i.e. the width of the rectangular LPF filter decreases) horizontal blurring in the image increases. When the limits of both $\text{abs}(u)$ and $\text{abs}(v)$ are less than 0.1 there no visible distinct dots; instead there regions that range in darkness/brightness.

7 Exercise 8

Similar to exercise 5 the image changes in pattern every time the code is run. The image shows sections that are concentrated with white and other sections with higher concentrated darkness. However, the dark/bright sections using the rectangular LPF filter are larger in area than the dark/bright sections using the circular filter. Similar to exercise 5, the surface shows a 3-D surface plot of the image where the brighter the region is in the image the higher it is on the z-axis of the surface. However, the surface for using the rectangular LPF filter has less fluctuations due to fewer bright/dark spots. Furthermore, the change in the shape of the surface is more noticeable using the rectangular LPF filter.

8 Exercise 9

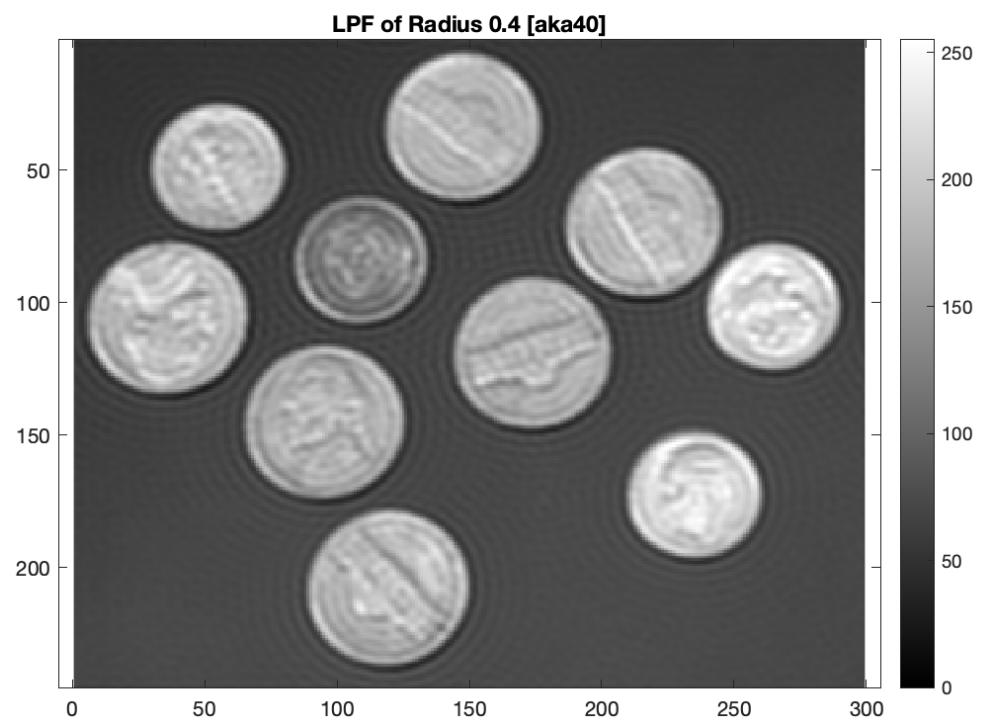
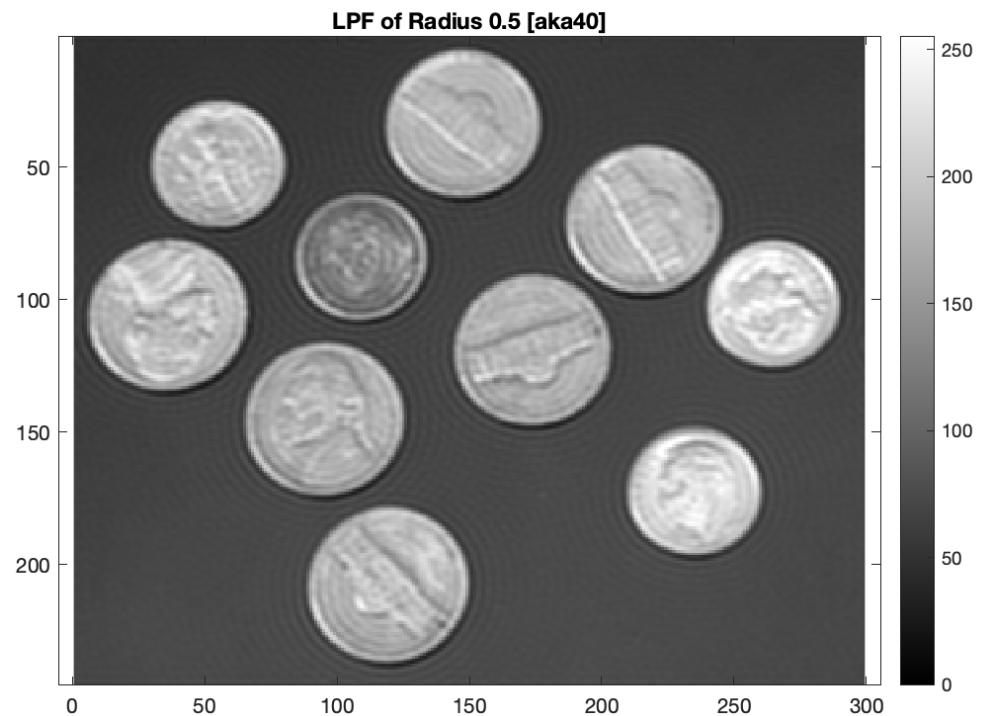
As the minimum of the $\text{abs}(u)$ increases (i.e. the height of the rectangular HPF filter increases) vertical blurring in the image decreases. As the minimum of the $\text{abs}(v)$ increases (i.e. the width of the rectangular HPF filter increases) horizontal blurring in the image decreases.

9 Exercise 10

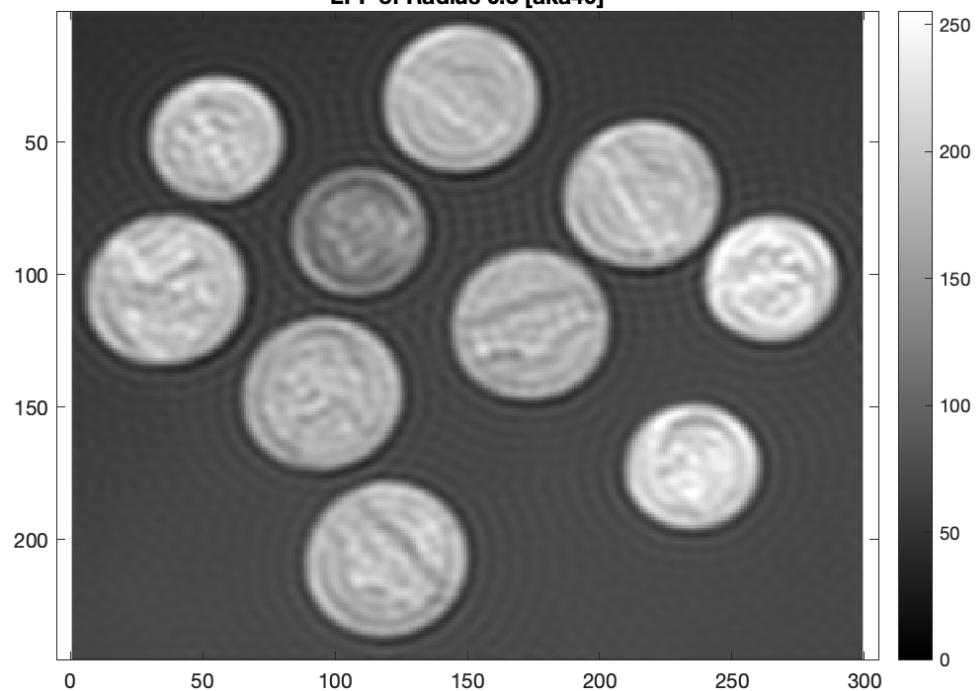
The higher the range of $\text{abs}(u)$ (i.e. the smaller the height of the inner white portion of the rectangular BPF) the lower the vertical blur. The higher the range of $\text{abs}(v)$ (i.e. the smaller the width of the inner white portion of the rectangular BPF) the lower the horizontal blur.

10 Graphs

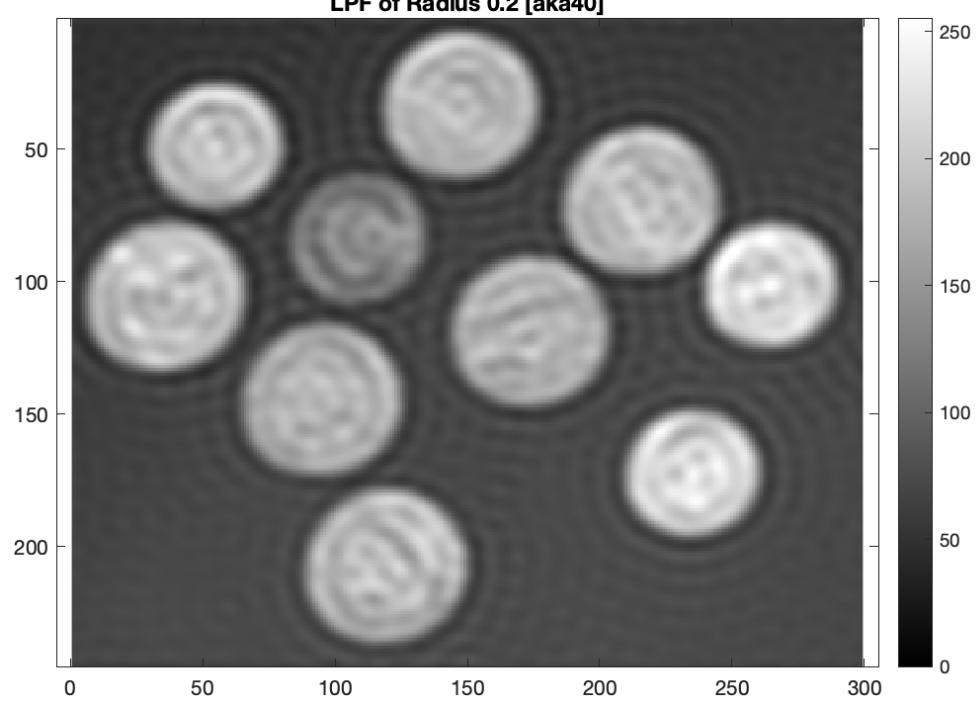
10.1 Exercise 3



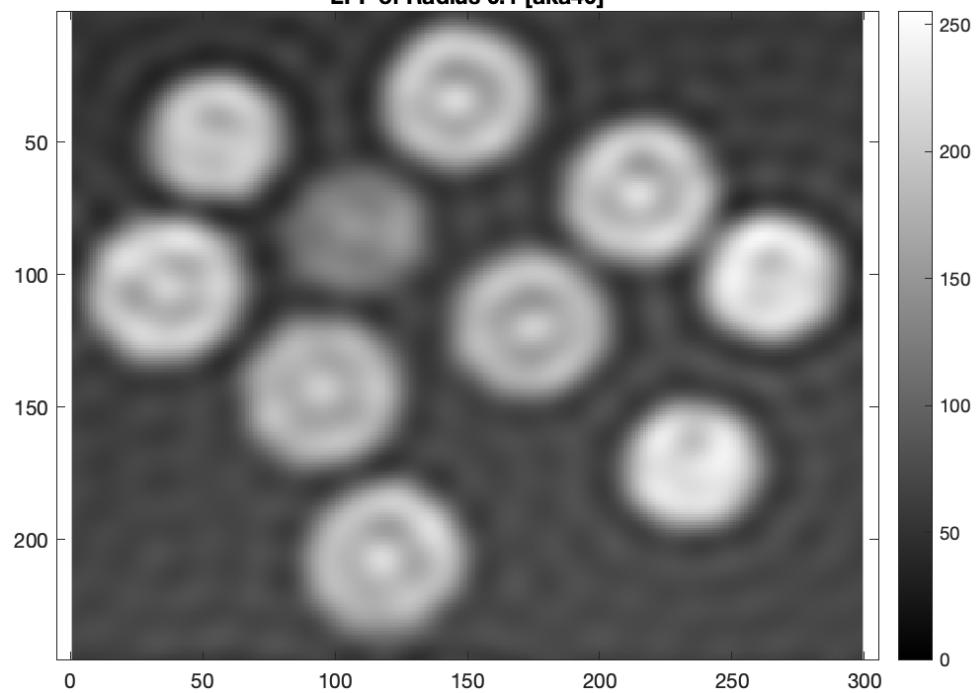
LPF of Radius 0.3 [aka40]



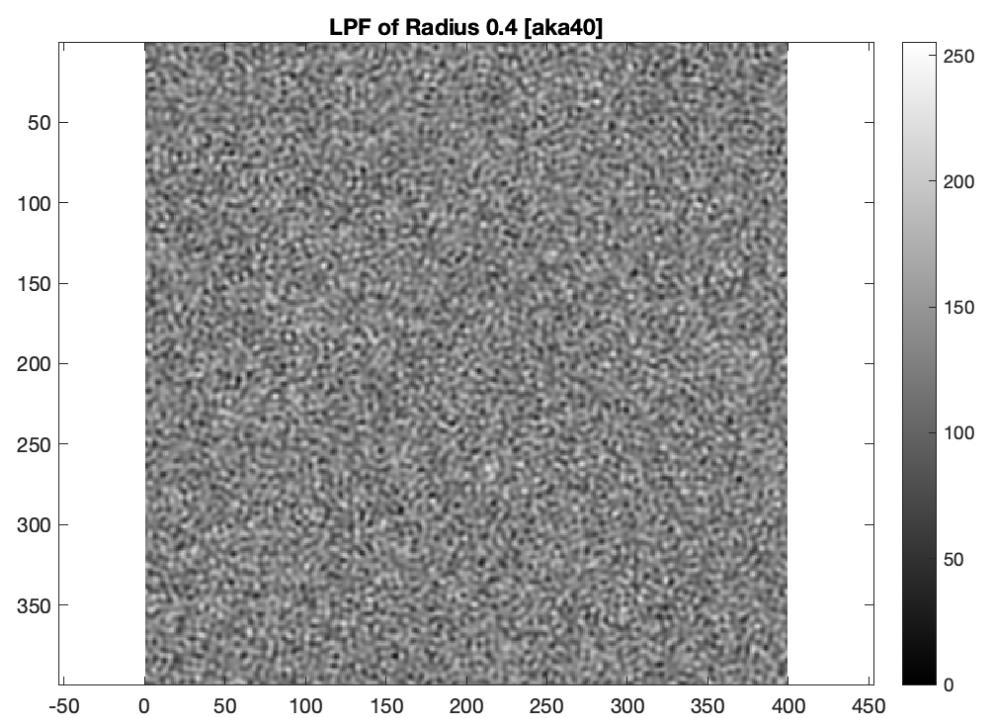
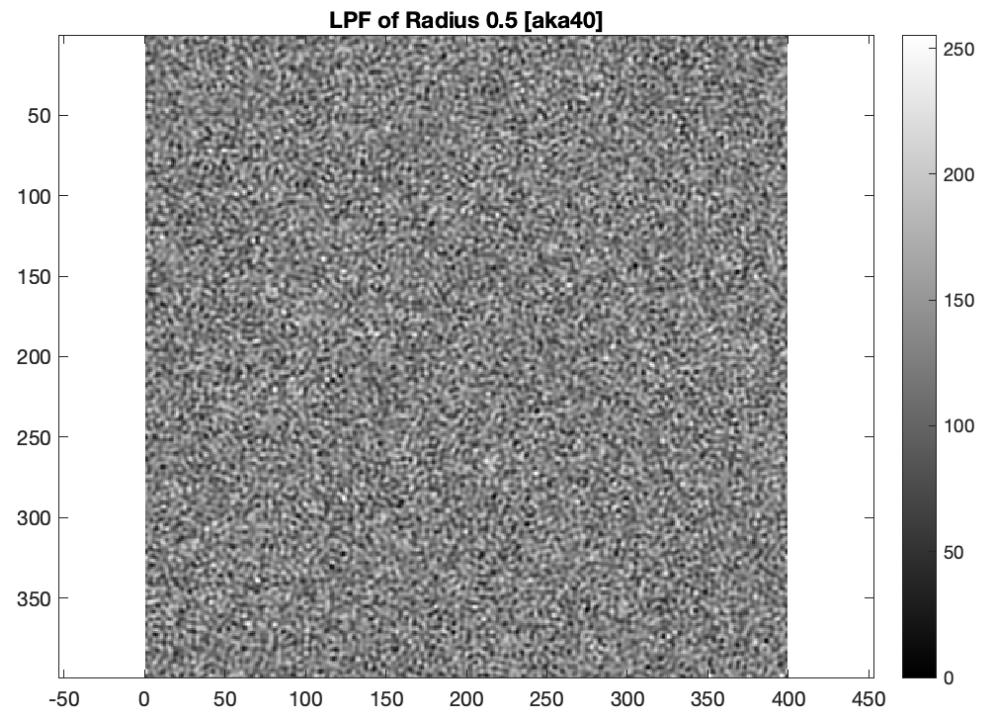
LPF of Radius 0.2 [aka40]



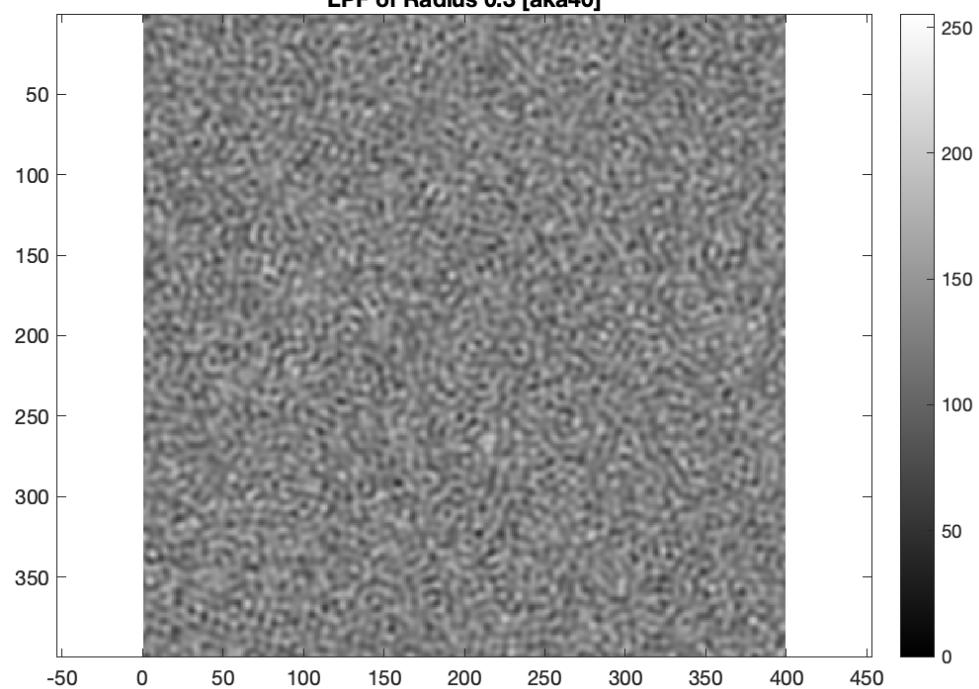
LPF of Radius 0.1 [aka40]



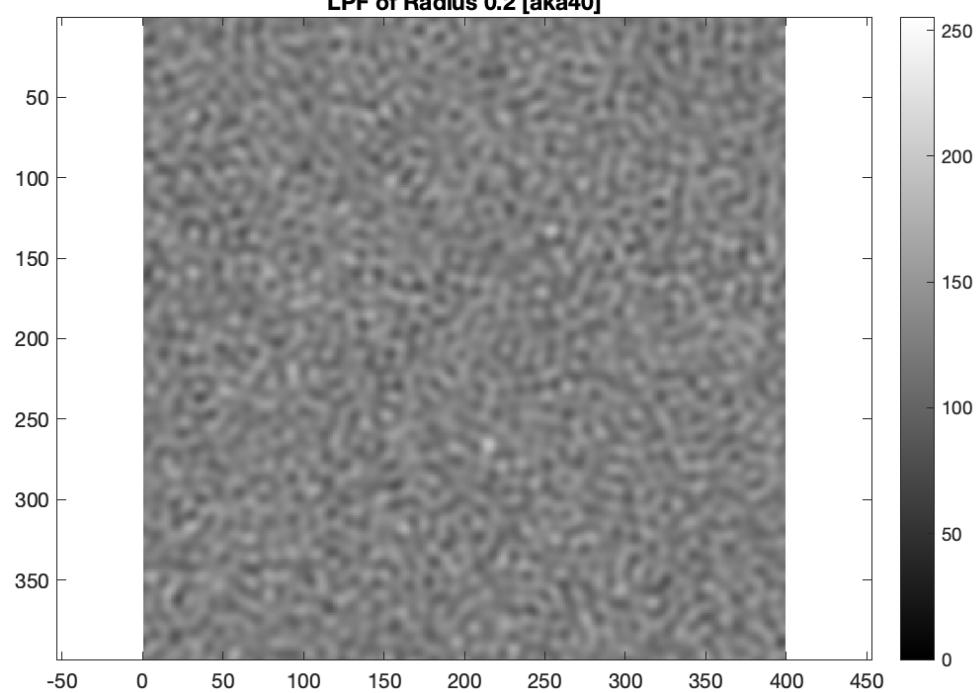
10.2 Exercise 4

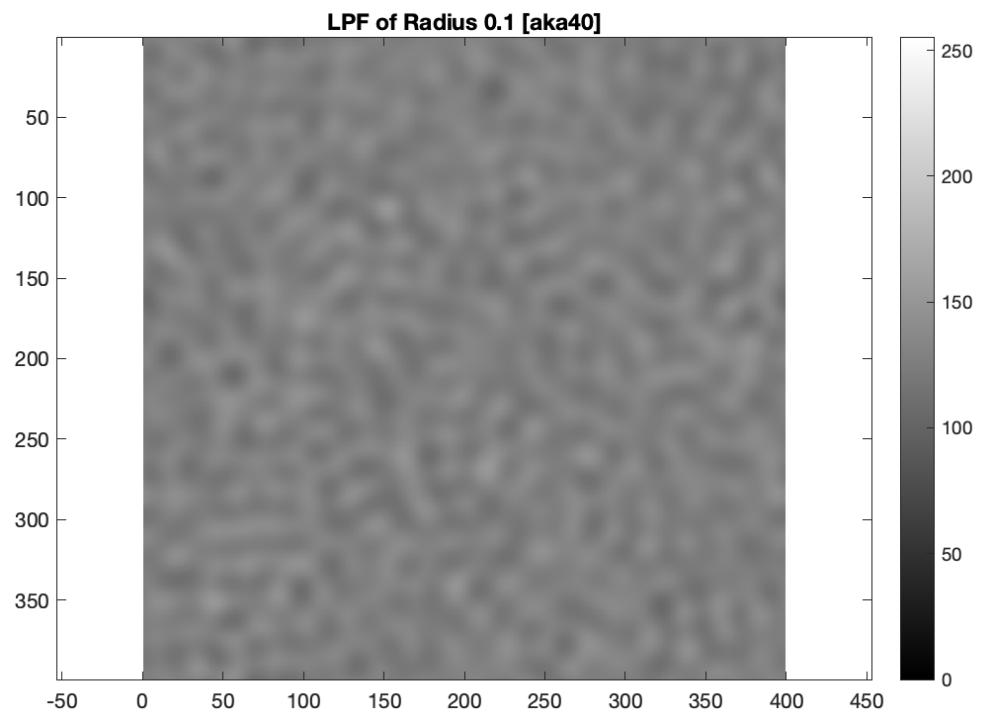


LPF of Radius 0.3 [aka40]

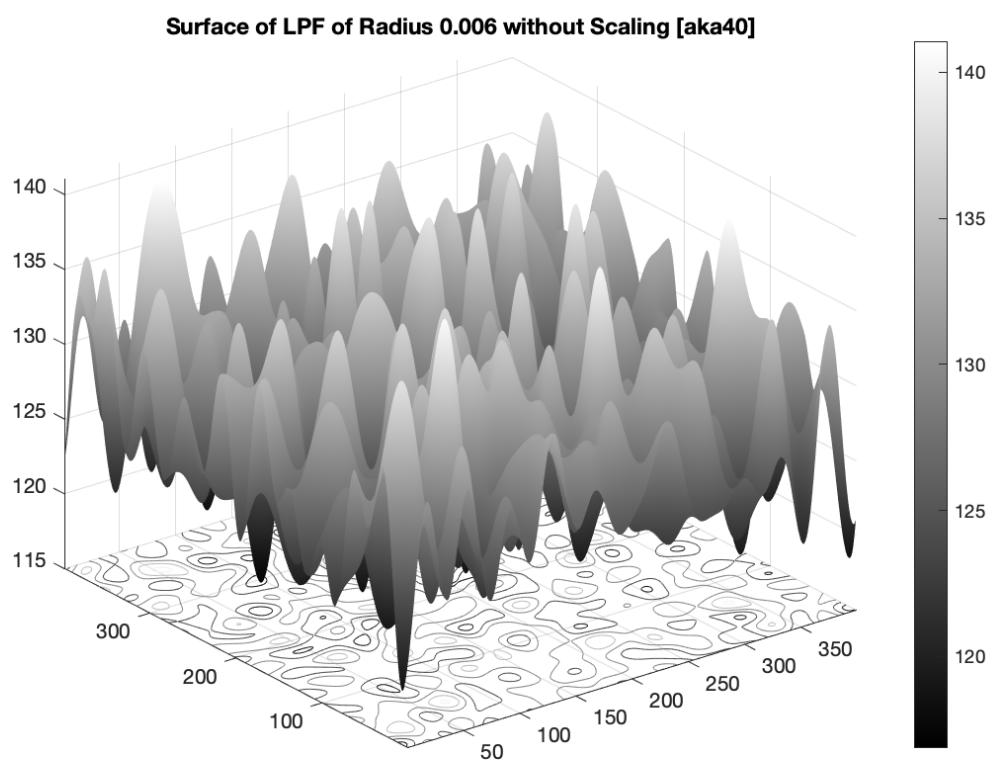
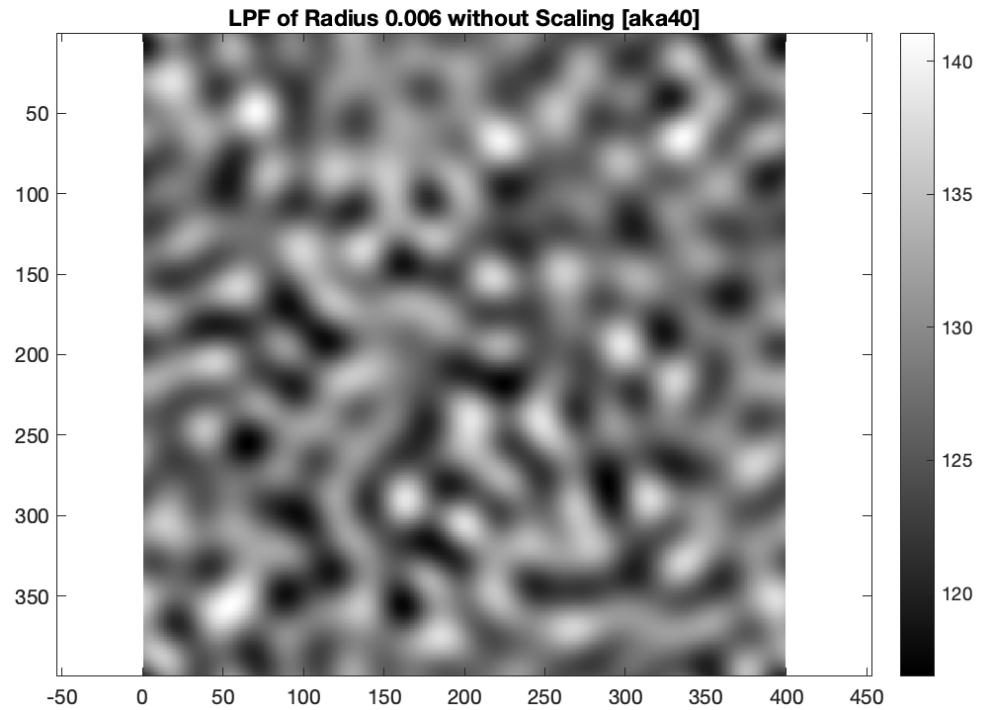


LPF of Radius 0.2 [aka40]

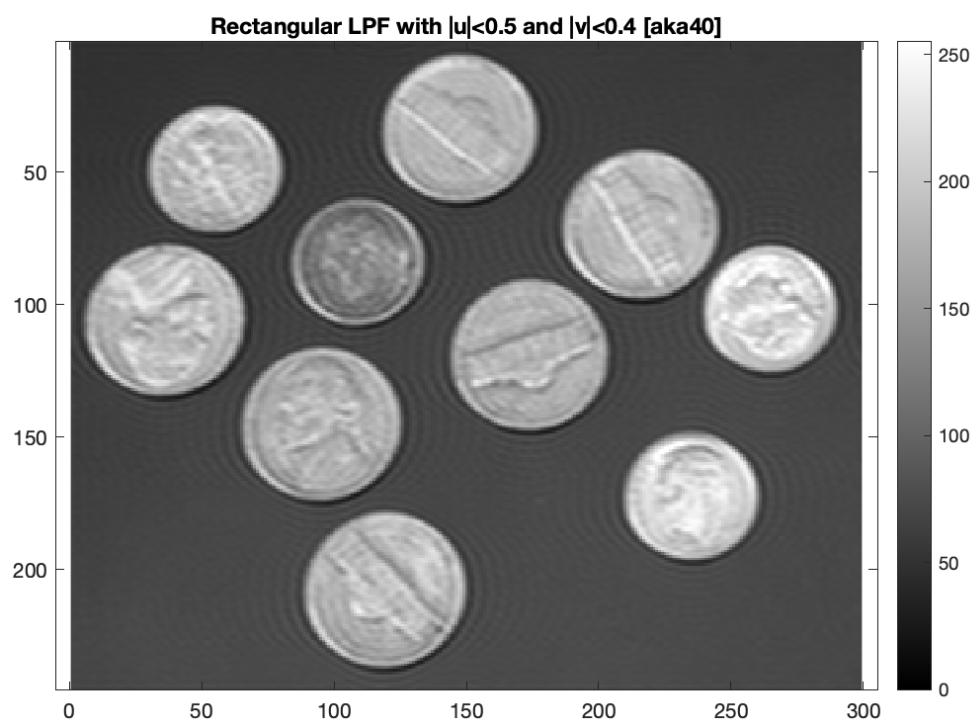
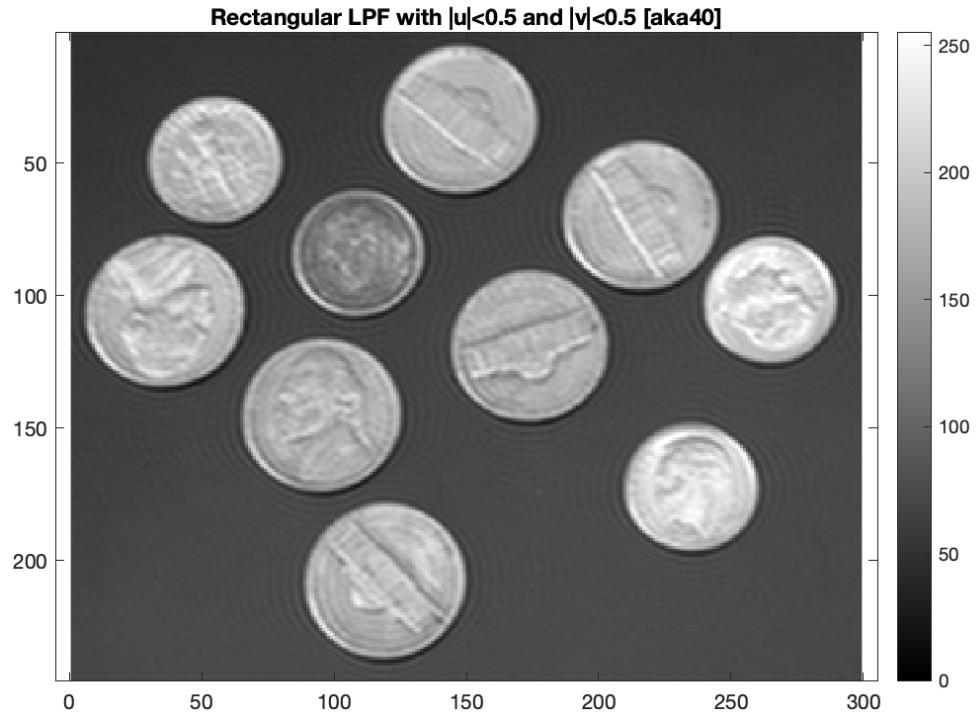




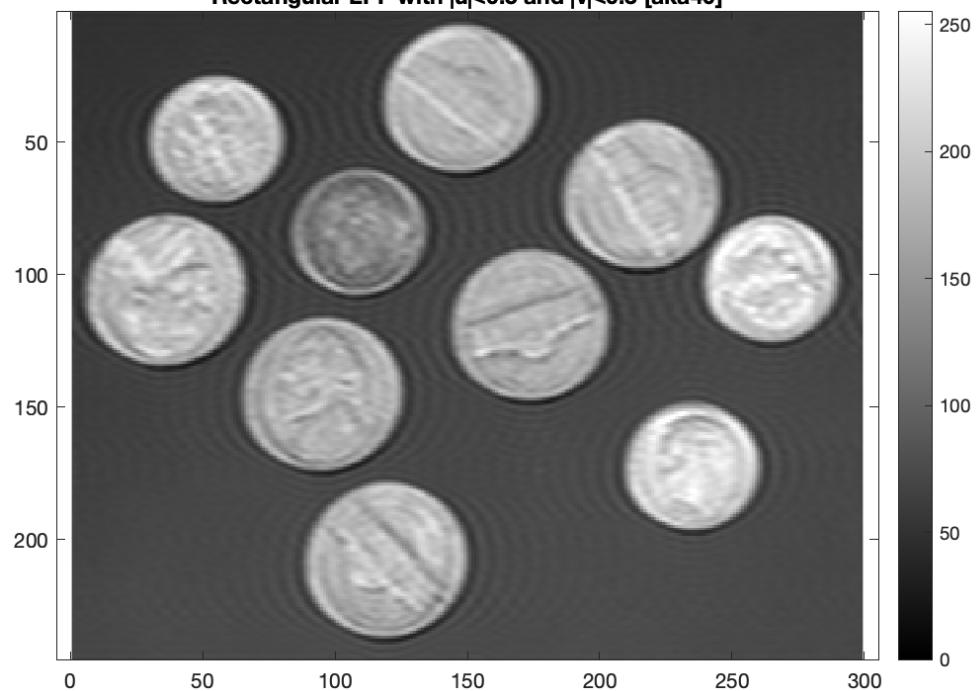
10.3 Exercise 5



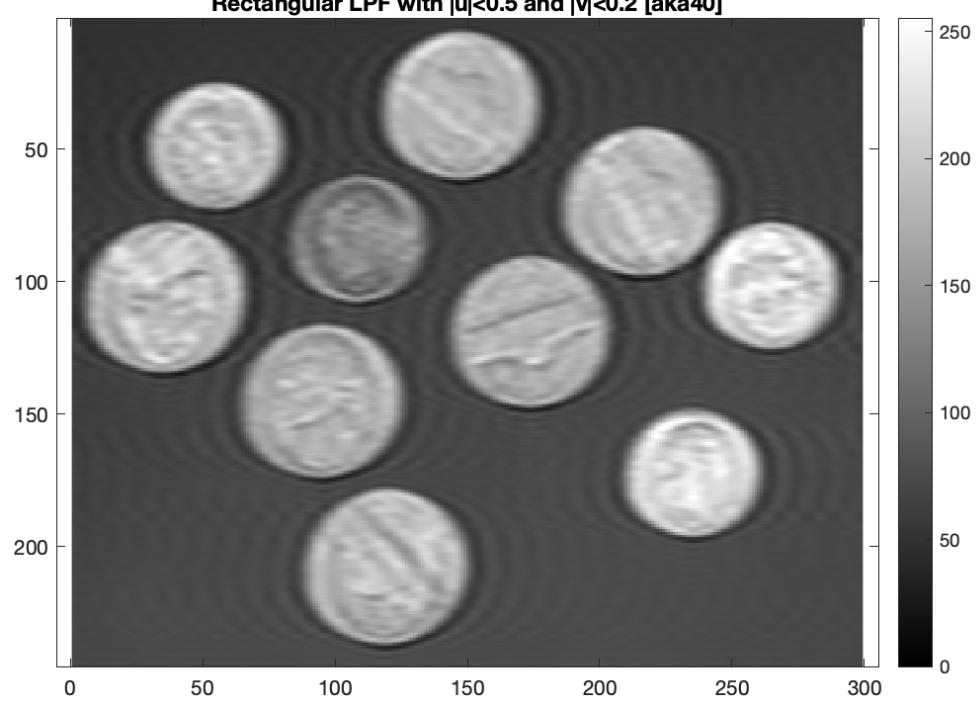
10.4 Exercise 6



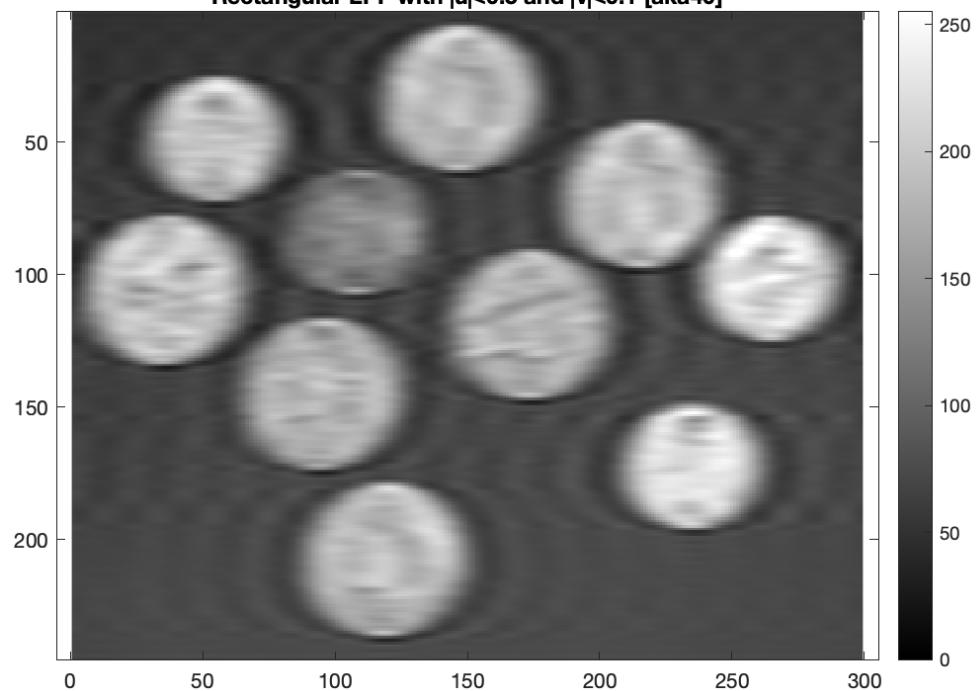
Rectangular LPF with $|u|<0.5$ and $|v|<0.3$ [aka40]



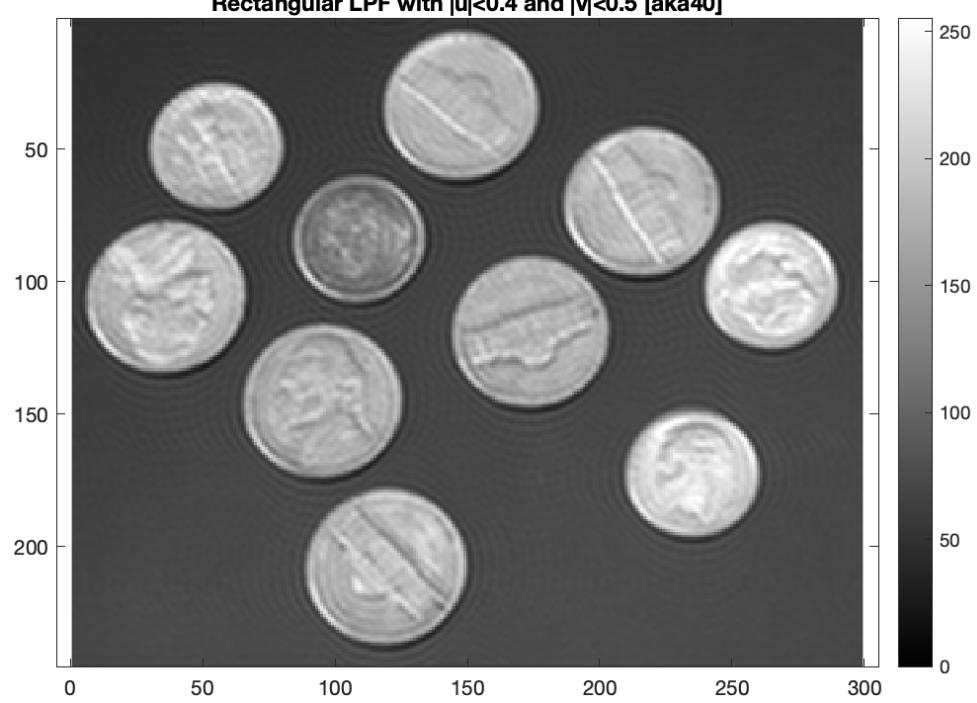
Rectangular LPF with $|u|<0.5$ and $|v|<0.2$ [aka40]



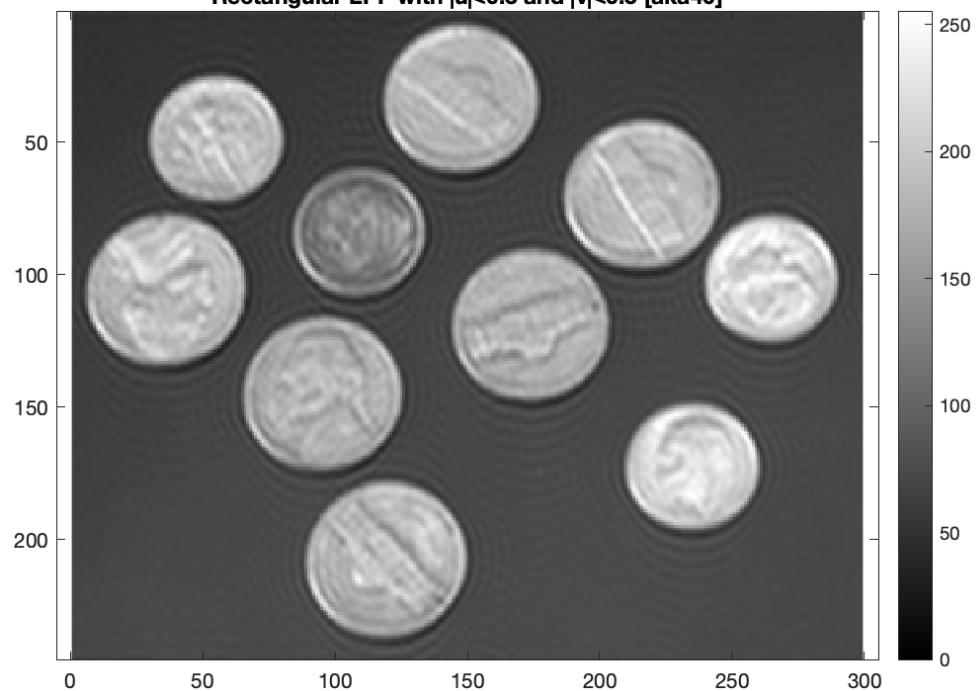
Rectangular LPF with $|u|<0.5$ and $|v|<0.1$ [aka40]



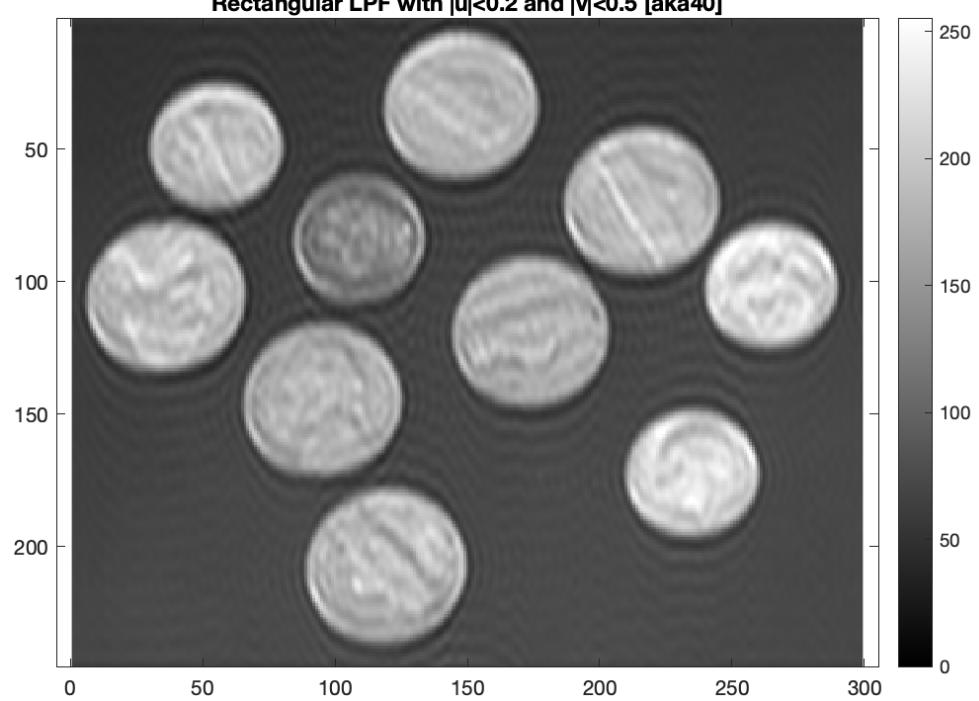
Rectangular LPF with $|u|<0.4$ and $|v|<0.5$ [aka40]



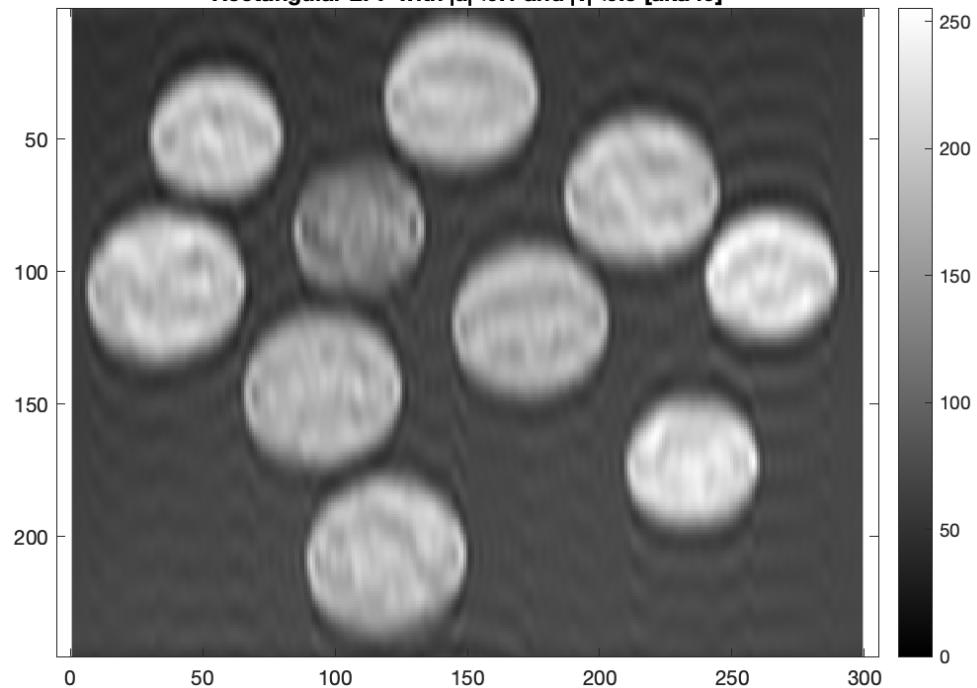
Rectangular LPF with $|u|<0.3$ and $|v|<0.5$ [aka40]



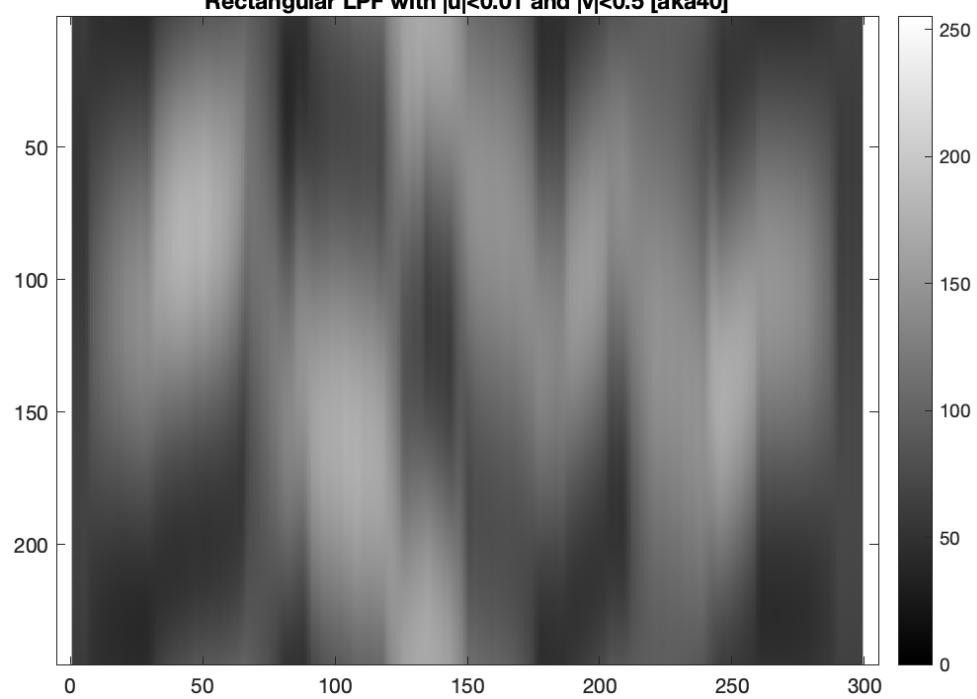
Rectangular LPF with $|u|<0.2$ and $|v|<0.5$ [aka40]



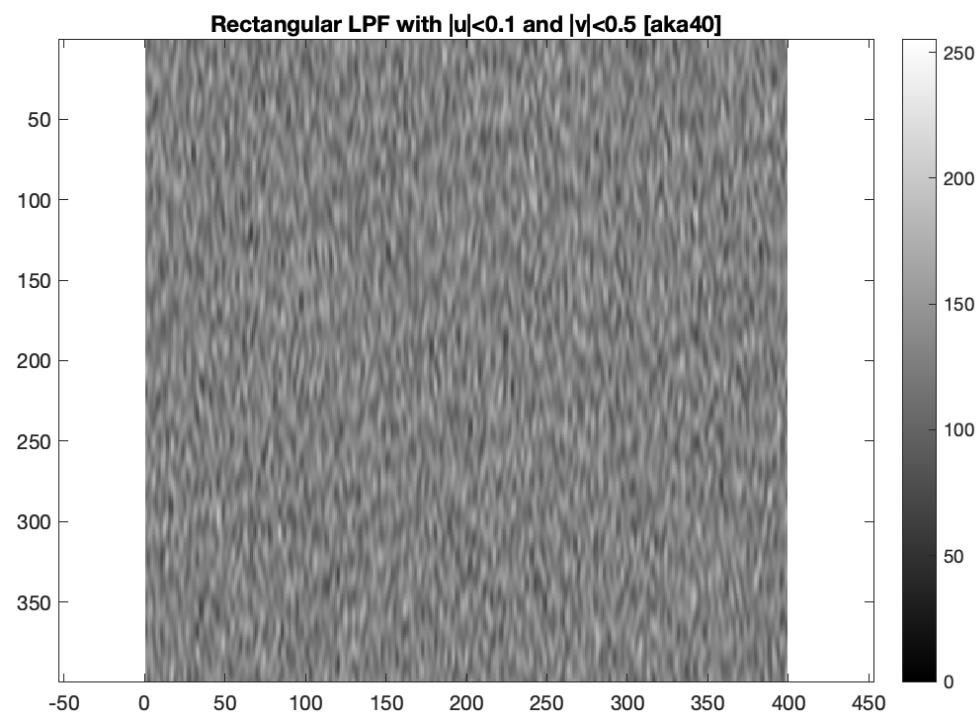
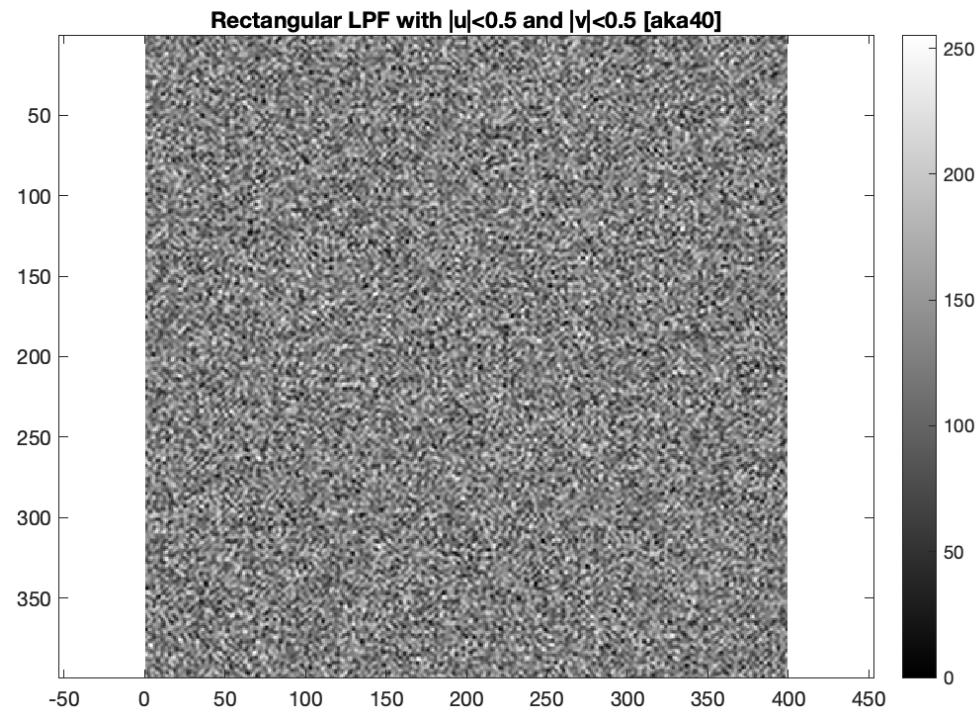
Rectangular LPF with $|u|<0.1$ and $|v|<0.5$ [aka40]



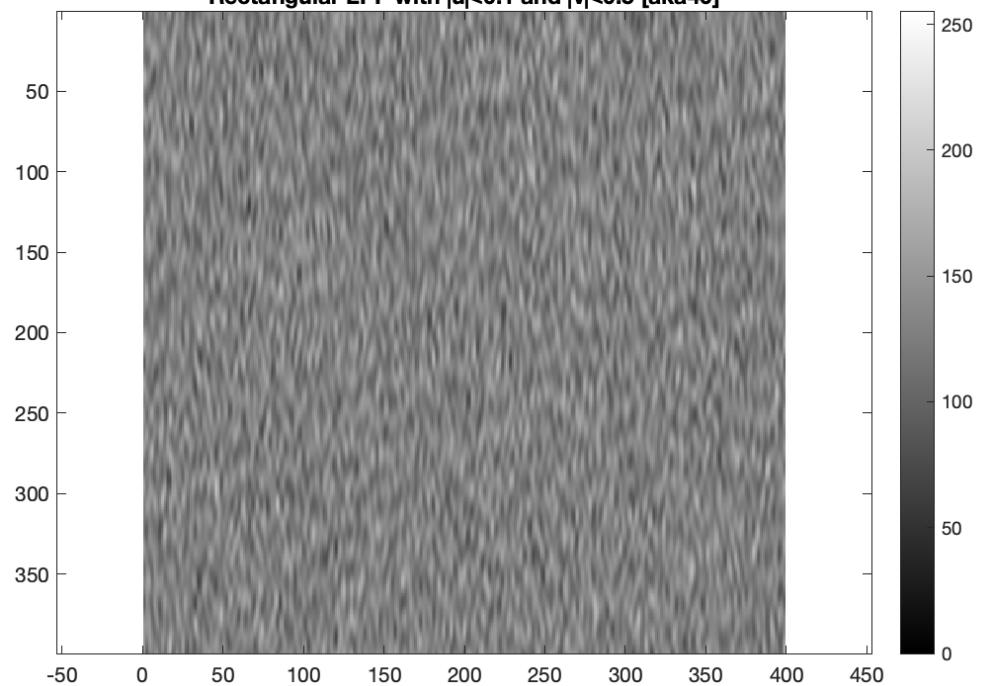
Rectangular LPF with $|u|<0.01$ and $|v|<0.5$ [aka40]



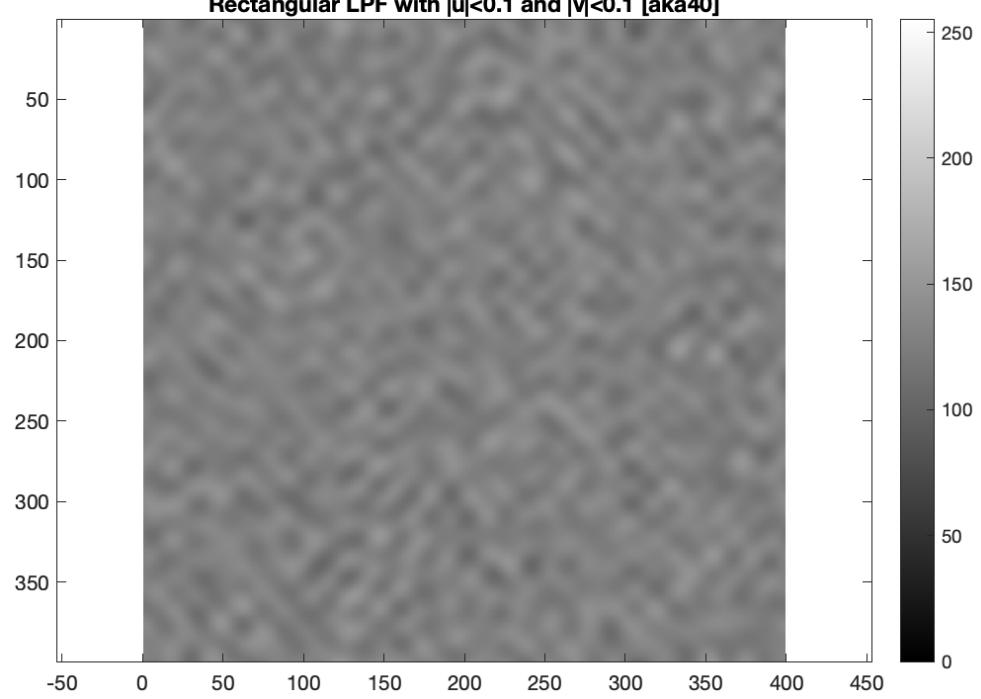
10.5 Exercise 7



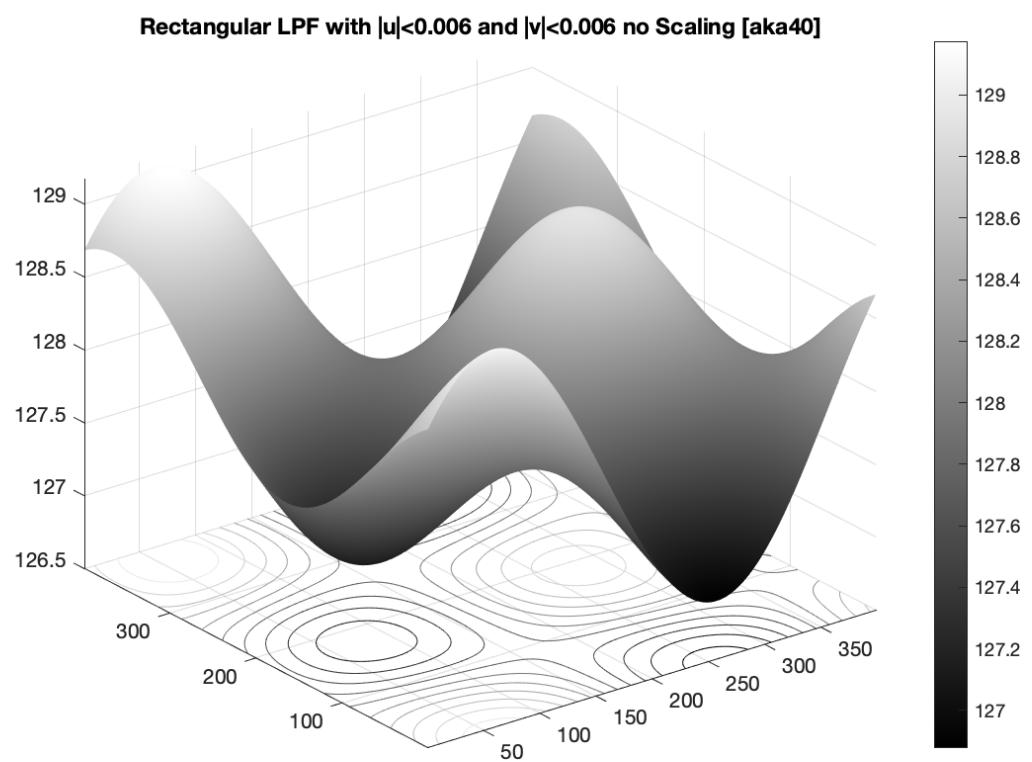
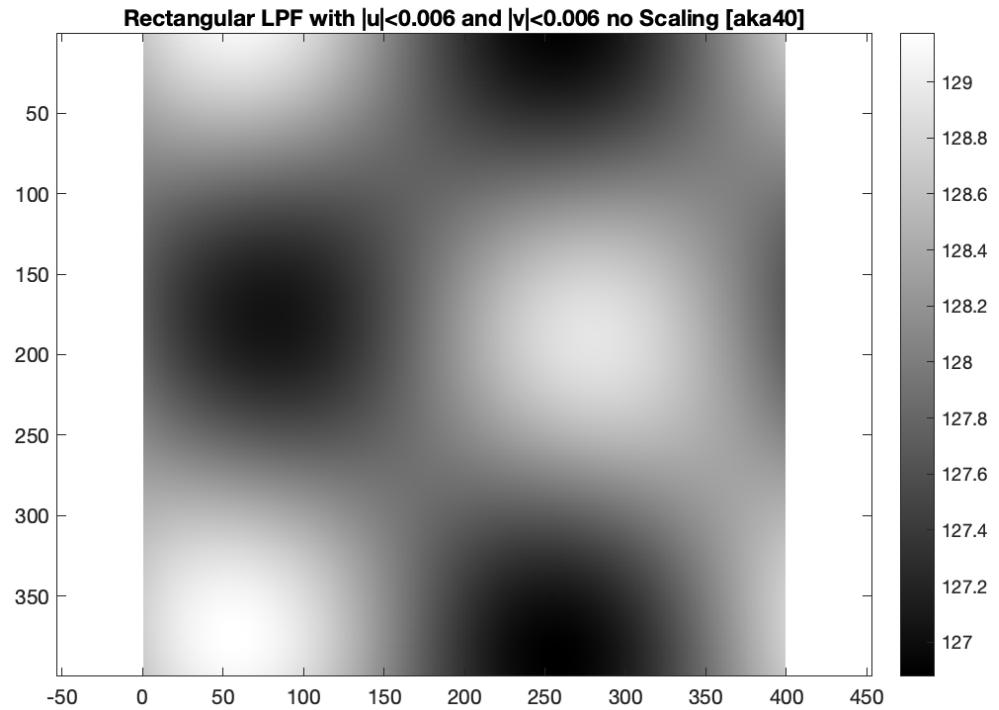
Rectangular LPF with $|u|<0.1$ and $|v|<0.5$ [aka40]



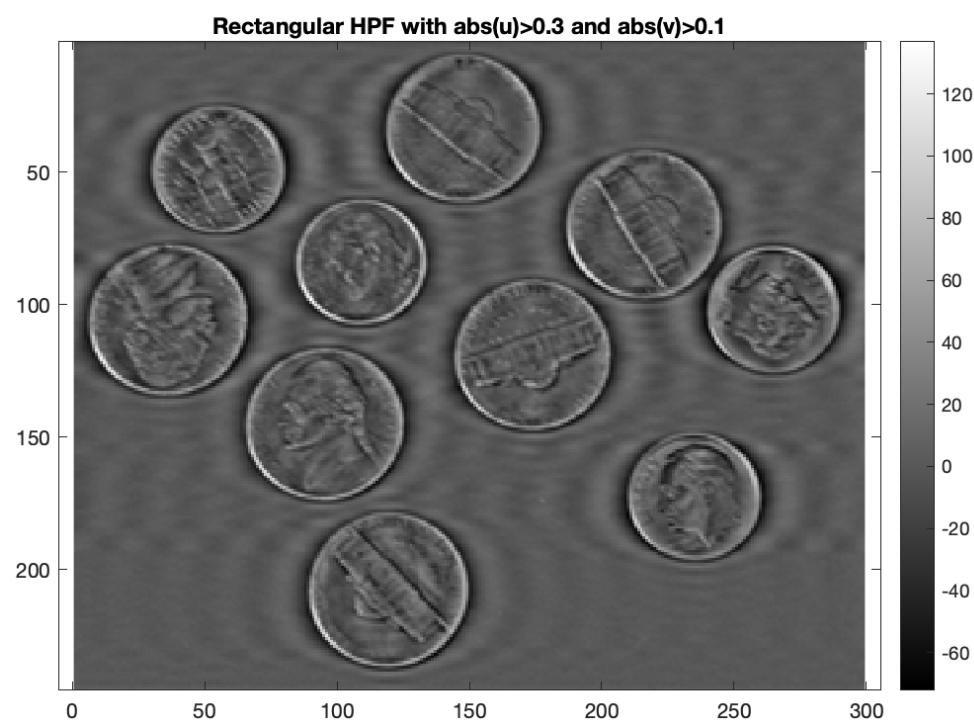
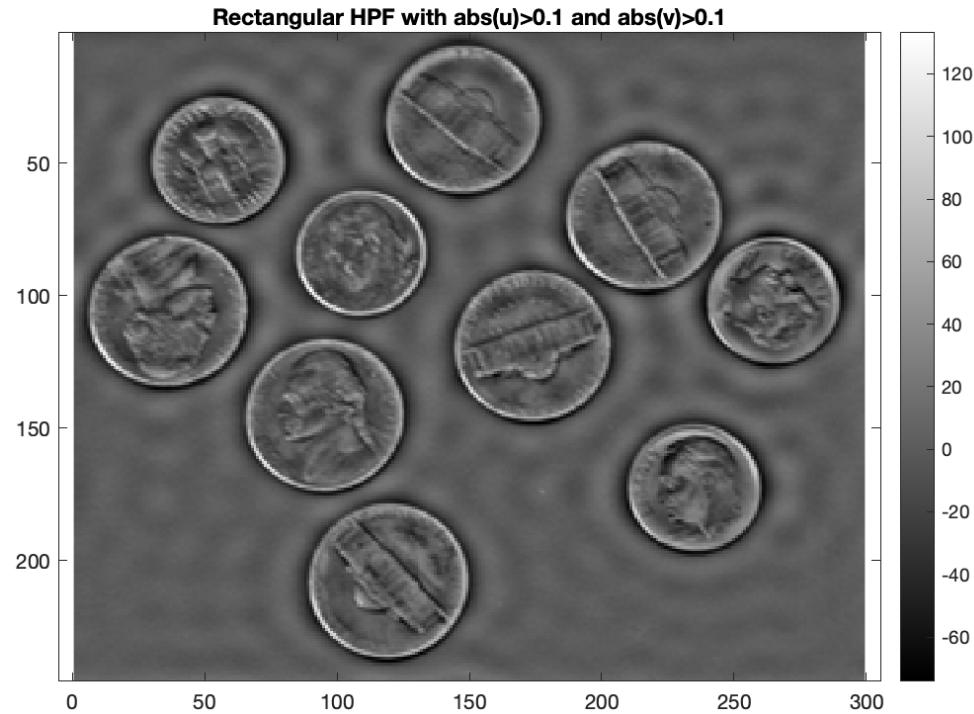
Rectangular LPF with $|u|<0.1$ and $|v|<0.1$ [aka40]



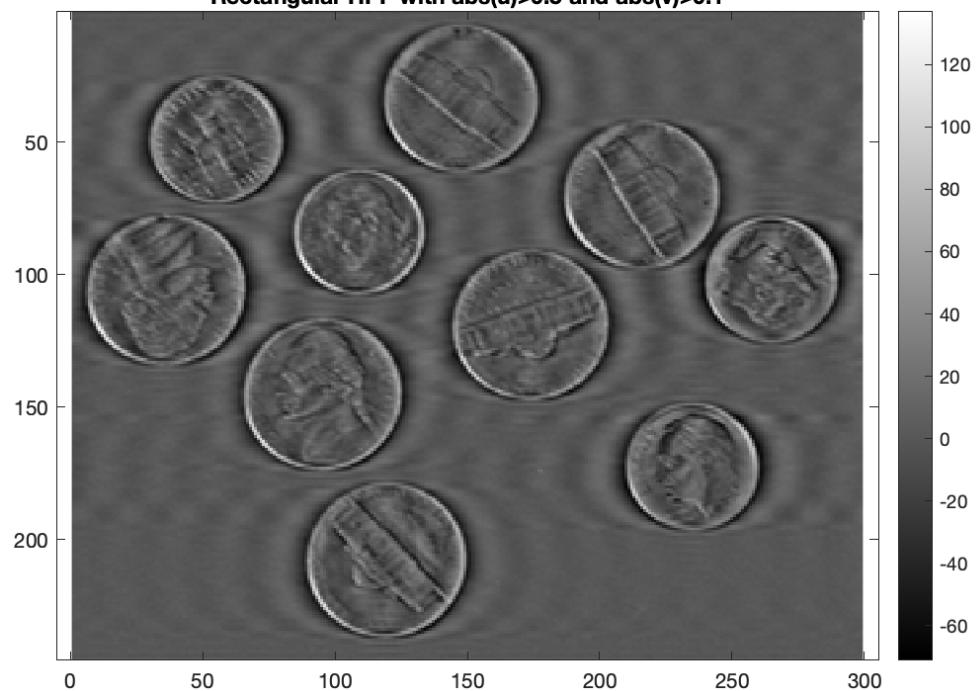
10.6 Exercise 8



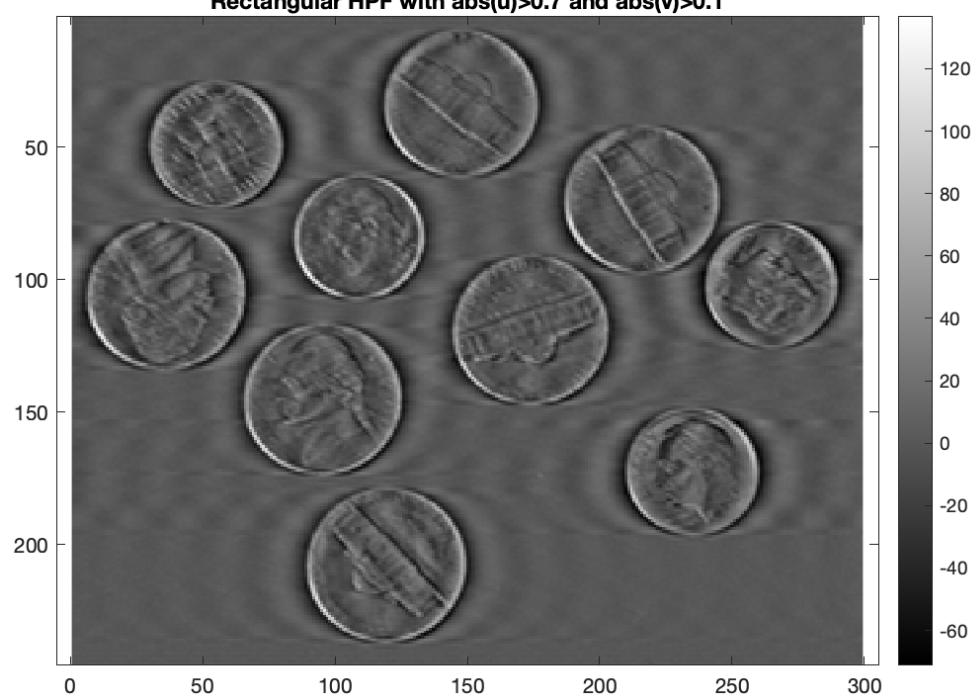
10.7 Exercise 9



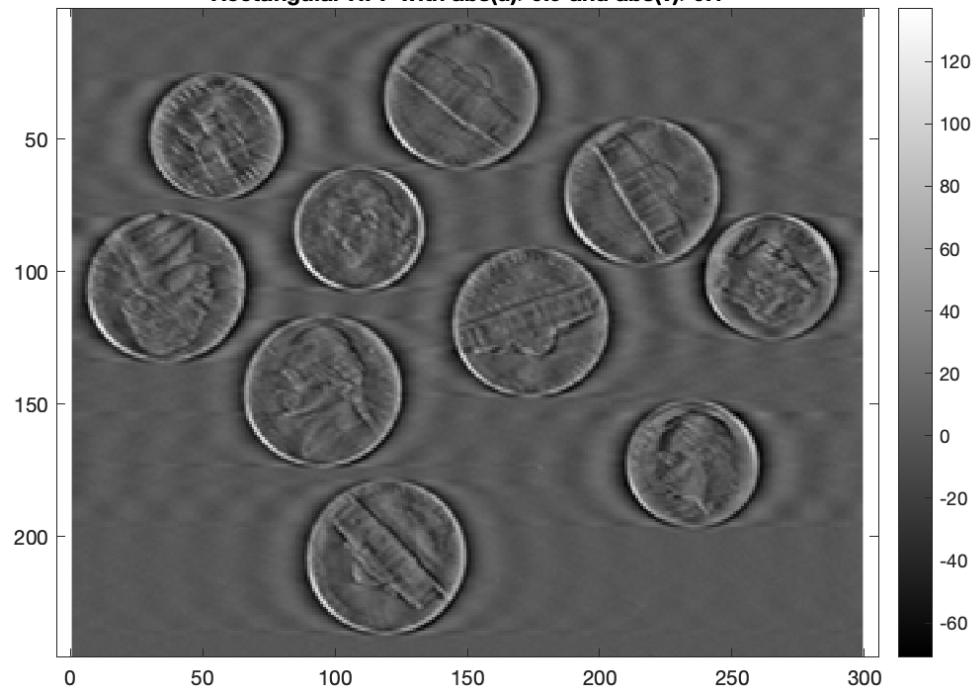
Rectangular HPF with $\text{abs}(u)>0.5$ and $\text{abs}(v)>0.1$



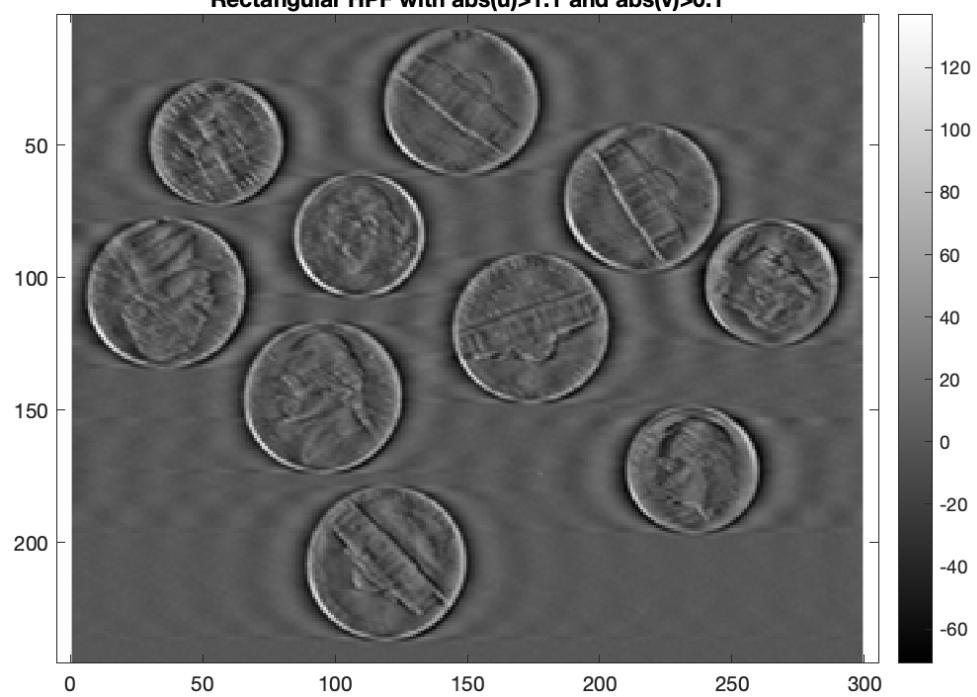
Rectangular HPF with $\text{abs}(u)>0.7$ and $\text{abs}(v)>0.1$



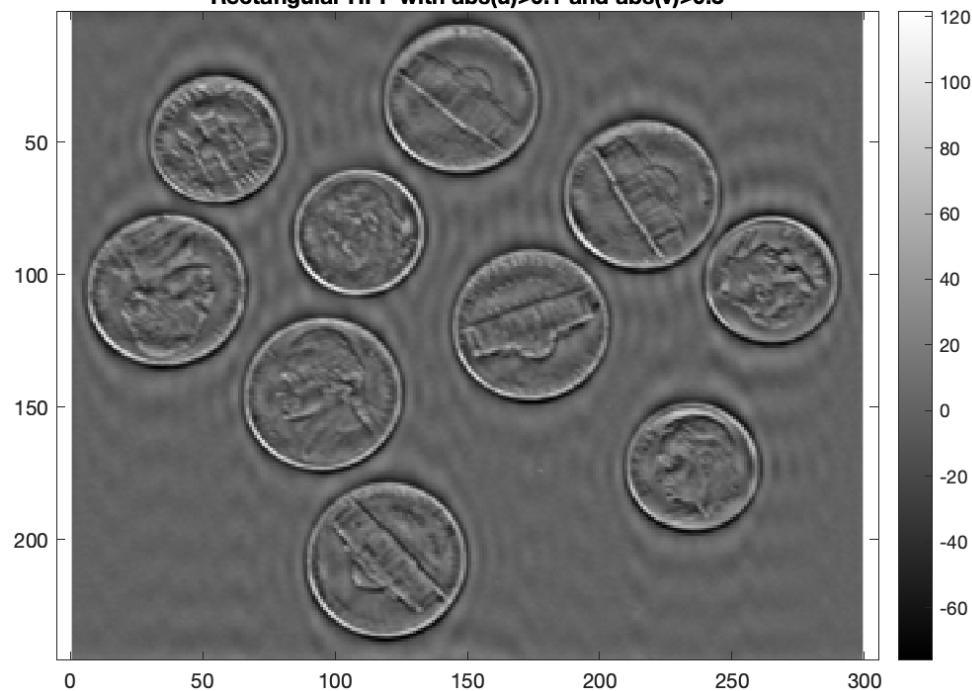
Rectangular HPF with $\text{abs}(u) > 0.9$ and $\text{abs}(v) > 0.1$



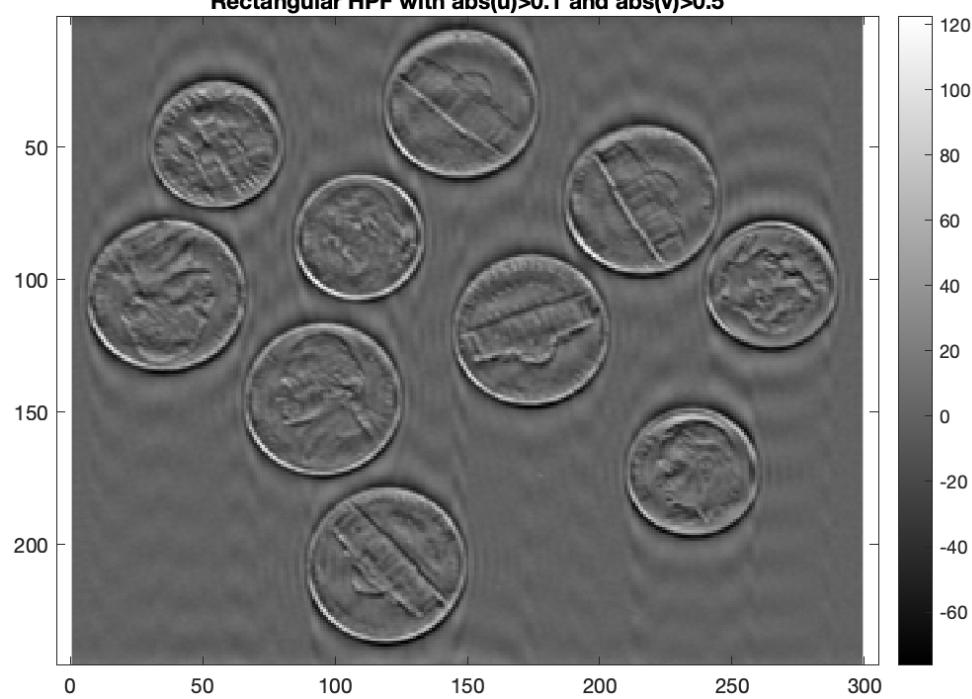
Rectangular HPF with $\text{abs}(u) > 1.1$ and $\text{abs}(v) > 0.1$



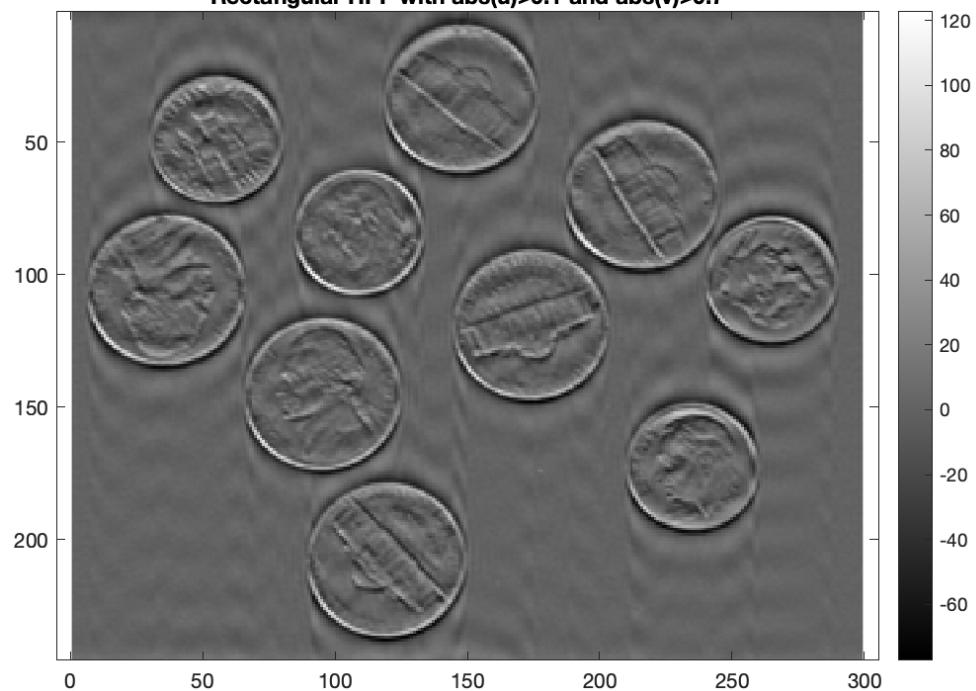
Rectangular HPF with $\text{abs}(u)>0.1$ and $\text{abs}(v)>0.3$



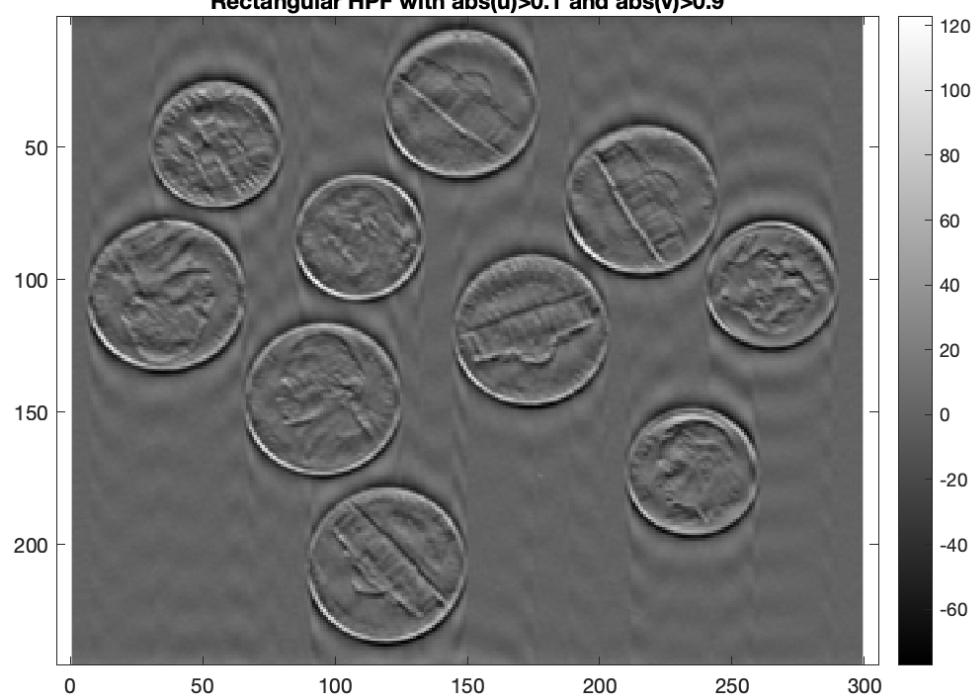
Rectangular HPF with $\text{abs}(u)>0.1$ and $\text{abs}(v)>0.5$



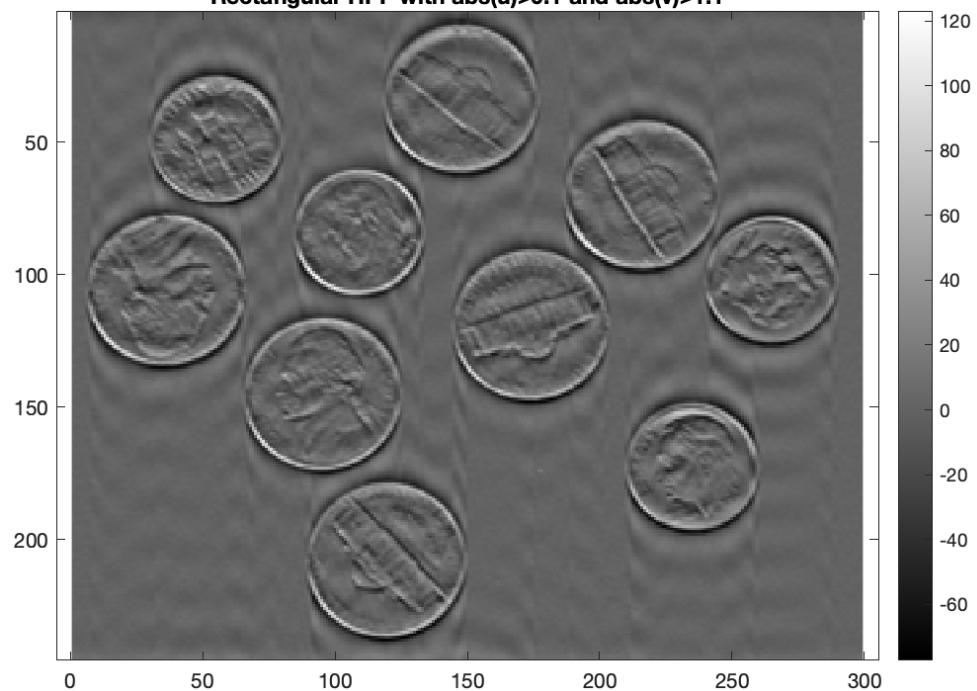
Rectangular HPF with $\text{abs}(u)>0.1$ and $\text{abs}(v)>0.7$



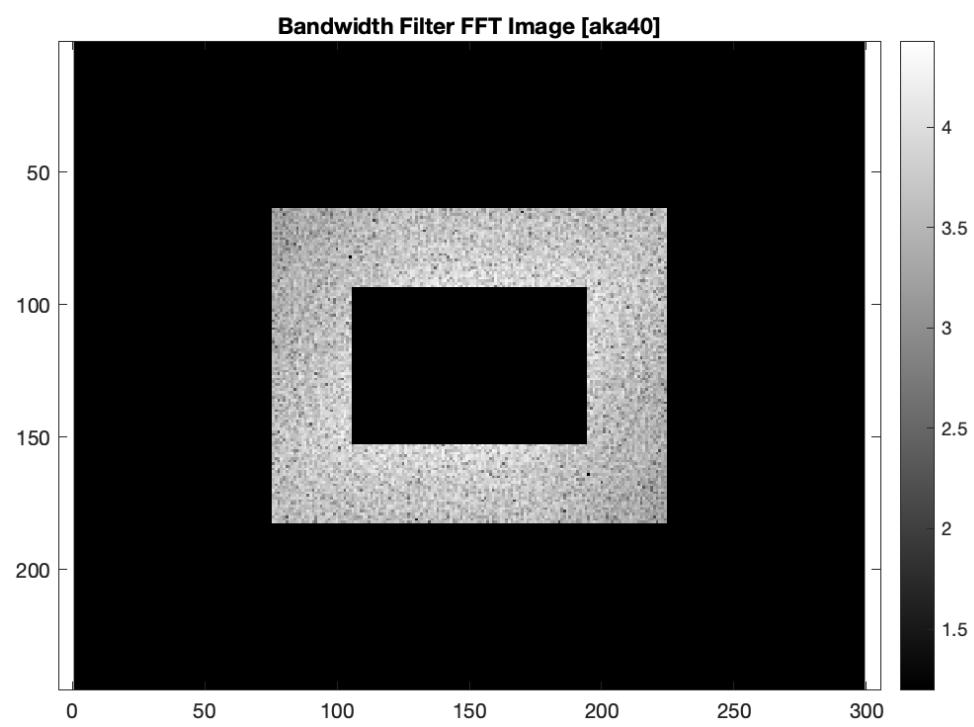
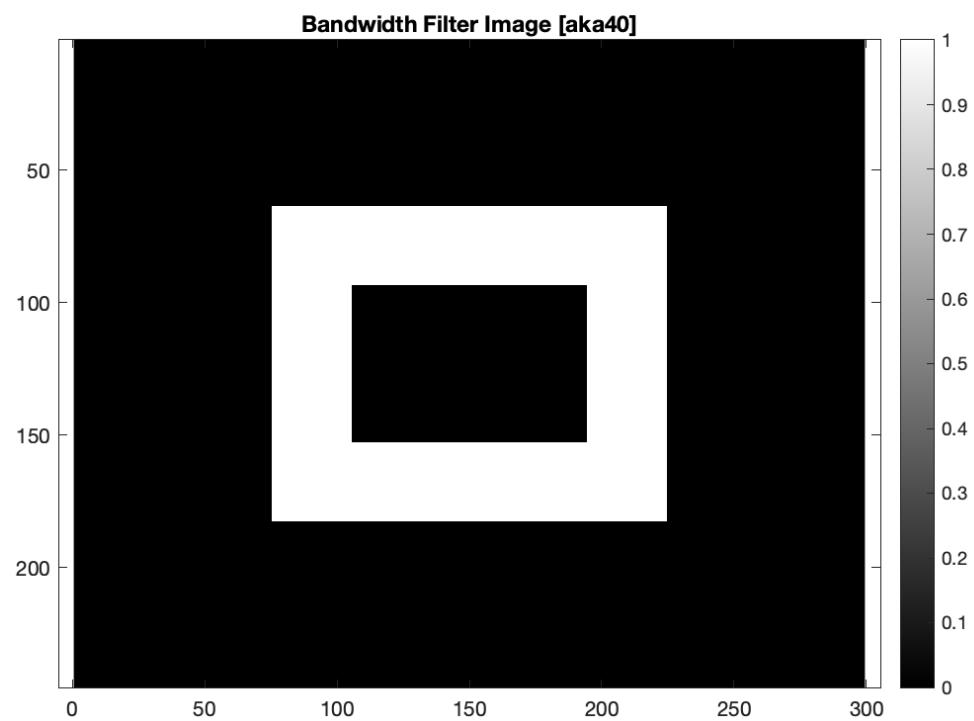
Rectangular HPF with $\text{abs}(u)>0.1$ and $\text{abs}(v)>0.9$



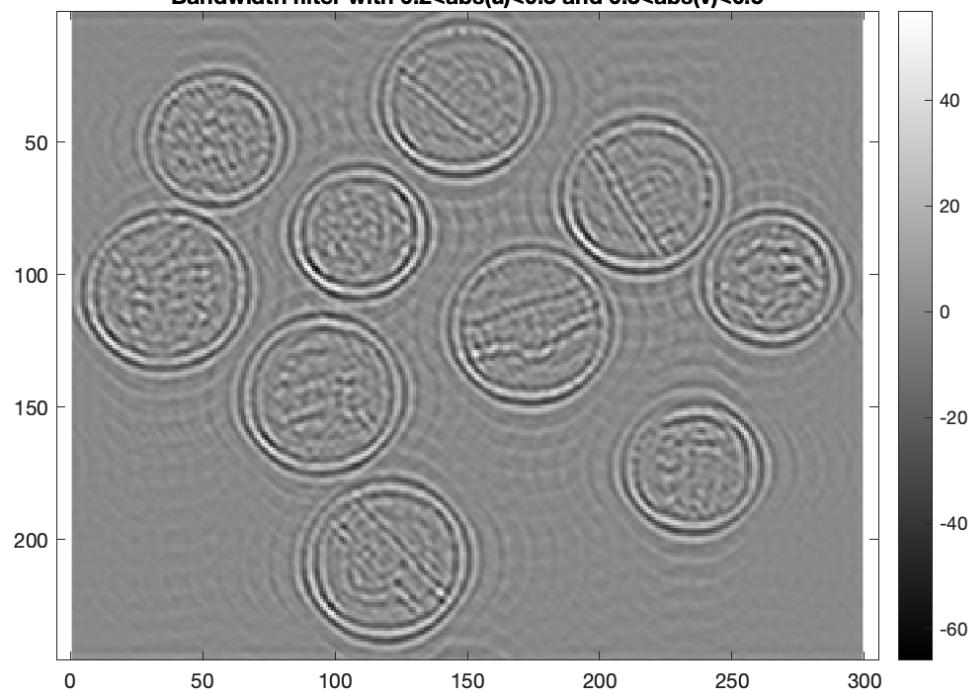
Rectangular HPF with $\text{abs}(u) > 0.1$ and $\text{abs}(v) > 1.1$



10.8 Exercise 10



Bandwidth filter with $0.2 < \text{abs}(u) < 0.3$ and $0.3 < \text{abs}(v) < 0.5$



11 Codes

11.1 Exercises 1 and 2

```
1 function [A,B,X] = analysis(arr)
2 M=length(arr);
3
4 A= zeros(1,M);
5 B= zeros(1,M);
6 X= zeros(1,M);
7 for k = 1:M
8     for m= 1:M
9         A(k) = A(k) + arr(m)* cos( 2 * pi/5 *(k-1)* (m-1));
10        B(k) = B(k) + arr(m)* sin( 2 * pi/5 *(k-1)* (m-1));
11        X(k) = X(k) + arr(m)* exp( -i *2 * pi/5*(k-1)* (m-1));
12    end
13 end
14 end

1 function x = trig_synth(A,B)
2 M = length(A);
3 x = zeros(1,M);
4
5 for m = 1:M
6     for k= 1:M
7         x(m) = x(m)+ A(k) * cos( 2 * pi/M *(k-1)* (m-1)) + ...
8                         B(k) * sin( 2 * pi/M *(k-1)* (m-1));
9     end
10 end
11 x= x/M;
12 end

1 function x = exp_synth(X)
2 M = length(X);
3 x = zeros(1,M);
4
5 for m = 1:M
6     for k= 1:M
7         x(m) = x(m) + X(k) * exp(i* 2 * pi/M *(k-1)* (m-1));
8     end
9 end
10 x= x/M;
11 end
```

11.2 Exercise 3

```
1 clear
2 x = imread('coins.png');
3 x = x(2:end, 2:end);
4 figure(1); clf
5 image(x); axis equal; colormap gray; colorbar
6 print -dpng trash.png
7
8 X = fft2(x);
9 Xs = fftshift(X);
10 figure(2); clf
11 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
12 print -dpng trash.png
13
14 [rows, cols] = size(x);
15 max_size = max(rows, cols);
16 rnorm = rows/max_size; cnorm = cols/max_size;
17 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
18     linspace(-rnorm, rnorm, rows));
19 filter = sqrt(u.^2+v.^2)<0.5;
20 figure(3); clf
21 imagesc(filter); axis equal; colormap gray; colorbar
22 print -dpng trash.png
23
24 Xsfiltered = Xs.*filter;
25 figure(4); clf
26 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
27 print -dpng trash.png
28
29 Xfiltered = ifftshift(Xsfiltered);
30 xfiltered = ifft2(Xfiltered);
31 figure(5); clf
32 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
33 title("LPF of Radius 0.5 [aka40]")
34 print -dpng IP2_EX3_Plot1.png
35
36 filter = sqrt(u.^2+v.^2)<0.4;
37 figure(6); clf
38 imagesc(filter); axis equal; colormap gray; colorbar
39 print -dpng trash.png
40
41 Xsfiltered = Xs.*filter;
42 figure(7); clf
43 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
44 print -dpng trash.png
45
46 Xfiltered = ifftshift(Xsfiltered);
47 xfiltered = ifft2(Xfiltered);
48 figure(8); clf
49 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
50 title("LPF of Radius 0.4 [aka40]")
51 print -dpng IP2_EX3_Plot2.png
52
53 filter = sqrt(u.^2+v.^2)<0.3;
54 figure(9); clf
55 imagesc(filter); axis equal; colormap gray; colorbar
```

```

56 print -dpng trash.png
57
58 Xsfiltered = Xs.*filter;
59 figure(10); clf
60 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
61 print -dpng trash.png
62
63 Xfiltered = ifftshift(Xsfiltered);
64 xfiltered = ifft2(Xfiltered);
65 figure(11); clf
66 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
67 title("LPF of Radius 0.3 [aka40]")
68 print -dpng IP2_EX3_Plot3.png
69
70
71 filter = sqrt(u.^2+v.^2)<0.2;
72 figure(12); clf
73 imagesc(filter); axis equal; colormap gray; colorbar
74 print -dpng trash.png
75
76 Xsfiltered = Xs.*filter;
77 figure(13); clf
78 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
79 print -dpng trash.png
80
81 Xfiltered = ifftshift(Xsfiltered);
82 xfiltered = ifft2(Xfiltered);
83 figure(14); clf
84 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
85 title("LPF of Radius 0.2 [aka40]")
86 print -dpng IP2_EX3_Plot4.png
87
88
89 filter = sqrt(u.^2+v.^2)<0.1;
90 figure(15); clf
91 imagesc(filter); axis equal; colormap gray; colorbar
92 print -dpng trash.png
93
94 Xsfiltered = Xs.*filter;
95 figure(16); clf
96 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
97 print -dpng trash.png
98
99 Xfiltered = ifftshift(Xsfiltered);
100 xfiltered = ifft2(Xfiltered);
101 figure(17); clf
102 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
103 title("LPF of Radius 0.1 [aka40]")
104 print -dpng IP2_EX3_Plot5.png

```

11.3 Exercise 4

```
1 clear
2 x = zeros(399,399);
3 x(:,:)= randi(255,399);
4
5 figure(1); clf
6 image(x); axis equal; colormap gray; colorbar
7 print -dpng trash.png
8
9 X = fft2(x);
10 Xs = fftshift(X);
11 figure(2); clf
12 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
13 print -dpng trash.png
14
15 [rows, cols] = size(x);
16 max_size = max(rows, cols);
17 rnorm = rows/max_size; cnorm = cols/max_size;
18 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
19     linspace(-rnorm, rnorm, rows)) ;
20 filter = sqrt(u.^2+v.^2)<0.5;
21 figure(3); clf
22 imagesc(filter); axis equal; colormap gray; colorbar
23 print -dpng trash.png
24
25 Xsfiltered = Xs.*filter;
26 figure(4); clf
27 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
28 print -dpng trash.png
29
30 Xfiltered = ifftshift(Xsfiltered);
31 xfiltered = ifft2(Xfiltered);
32 figure(5); clf
33 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
34 title("LPF of Radius 0.5 [aka40]")
35 print -dpng IP2_EX4_Plot1.png
36
37 filter = sqrt(u.^2+v.^2)<0.4;
38 figure(6); clf
39 imagesc(filter); axis equal; colormap gray; colorbar
40 print -dpng trash.png
41
42 Xsfiltered = Xs.*filter;
43 figure(7); clf
44 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
45 print -dpng trash.png
46
47 Xfiltered = ifftshift(Xsfiltered);
48 xfiltered = ifft2(Xfiltered);
49 figure(8); clf
50 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
51 title("LPF of Radius 0.4 [aka40]")
52 print -dpng IP2_EX4_Plot2.png
53
54 filter = sqrt(u.^2+v.^2)<0.3;
55 figure(9); clf
```

```

56 imagesc(filter); axis equal; colormap gray; colorbar
57 print -dpng trash.png
58
59 Xsfiltered = Xs.*filter;
60 figure(10); clf
61 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
62 print -dpng trash.png
63
64 Xfiltered = ifftshift(Xsfiltered);
65 xfiltered = ifft2(Xfiltered);
66 figure(11); clf
67 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
68 title("LPF of Radius 0.3 [aka40]")
69 print -dpng IP2_EX4_Plot3.png
70
71
72 filter = sqrt(u.^2+v.^2)<0.2;
73 figure(12); clf
74 imagesc(filter); axis equal; colormap gray; colorbar
75 print -dpng trash.png
76
77 Xsfiltered = Xs.*filter;
78 figure(13); clf
79 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
80 print -dpng trash.png
81
82 Xfiltered = ifftshift(Xsfiltered);
83 xfiltered = ifft2(Xfiltered);
84 figure(14); clf
85 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
86 title("LPF of Radius 0.2 [aka40]")
87 print -dpng IP2_EX4_Plot4.png
88
89
90 filter = sqrt(u.^2+v.^2)<0.1;
91 figure(15); clf
92 imagesc(filter); axis equal; colormap gray; colorbar
93 print -dpng trash.png
94
95 Xsfiltered = Xs.*filter;
96 figure(16); clf
97 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
98 print -dpng trash.png
99
100 Xfiltered = ifftshift(Xsfiltered);
101 xfiltered = ifft2(Xfiltered);
102 figure(17); clf
103 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
104 title("LPF of Radius 0.1 [aka40]")
105 print -dpng IP2_EX4_Plot5.png

```

11.4 Exercise 5

```
1 clear
2 x = zeros(399,399);
3 x(:,:)= randi(255,399);
4
5 figure(1); clf
6 image(x); axis equal; colormap gray; colorbar
7 print -dpng trash.png
8
9 X = fft2(x);
10 Xs = fftshift(X);
11 figure(2); clf
12 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
13 print -dpng trash.png
14
15 [rows, cols] = size(x);
16 max_size = max(rows, cols);
17 rnorm = rows/max_size; cnorm = cols/max_size;
18 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
19     linspace(-rnorm, rnorm, rows)) ;
20 filter = sqrt(u.^2+v.^2)<0.006;
21 figure(3); clf
22 imagesc(filter); axis equal; colormap gray; colorbar
23 print -dpng trash.png
24
25 Xsfiltered = Xs.*filter;
26 figure(4); clf
27 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
28 print -dpng trash.png
29
30 Xfiltered = ifftshift(Xsfiltered);
31 xfiltered = ifft2(Xfiltered);
32 figure(5); clf
33 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
34 title("LPF of Radius 0.006 [aka40]")
35 print -dpng IP2_EX5_Plot1.png
36
37 filter = sqrt(u.^2+v.^2)<0.06;
38
39 Xsfiltered = Xs.*filter;
40 Xfiltered = ifftshift(Xsfiltered);
41 xfiltered = ifft2(Xfiltered);
42 figure(6); clf
43 imagesc(xfiltered); axis equal; colormap gray; colorbar
44 title("LPF of Radius 0.006 without Scaling [aka40]")
45 print -dpng IP2_EX5_Plot6.png
46
47 figure(7); clf
48 surf(xfiltered); colormap gray; shading interp; colorbar
49 title("Surface of LPF of Radius 0.006 without Scaling [aka40]")
50 print -dpng IP2_EX5_Plot7.png
```

11.5 Exercise 6

```
1 clear
2 x = imread('coins.png');
3 x = x(2:end, 2:end);
4 figure(1); clf
5 image(x); axis equal; colormap gray; colorbar
6 print -dpng trash.png
7
8 X = fft2(x);
9 Xs = fftshift(X);
10 figure(2); clf
11 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
12 print -dpng trash.png
13
14 [rows, cols] = size(x);
15 max_size = max(rows, cols);
16 rnorm = rows/max_size; cnorm = cols/max_size;
17 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
18     linspace(-rnorm, rnorm, rows));
19 filter = (abs(u)<0.5) & (abs(v)<0.5);
20 figure(3); clf
21 imagesc(filter); axis equal; colormap gray; colorbar
22 print -dpng trash.png
23
24 Xsfiltered = Xs.*filter;
25 figure(4); clf
26 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
27 print -dpng trash.png
28
29 Xfiltered = ifftshift(Xsfiltered);
30 xfiltered = ifft2(Xfiltered);
31 figure(5); clf
32 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
33 print -dpng trash.png
34
35 title("Rectangular LPF with |u|<0.5 and |v|<0.5 [aka40]")
36
37 print -dpng IP2_EX6_Plot1.png
38
39
40 filter = (abs(u)<0.5) & (abs(v)<0.4);
41 figure(6); clf
42 imagesc(filter); axis equal; colormap gray; colorbar
43 print -dpng trash.png
44
45 Xsfiltered = Xs.*filter;
46 figure(7); clf
47 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
48 print -dpng trash.png
49
50 Xfiltered = ifftshift(Xsfiltered);
51 xfiltered = ifft2(Xfiltered);
52 figure(8); clf
53 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
54 print -dpng trash.png
55
```

```

56 title("Rectangular LPF with |u|<0.5 and |v|<0.4 [aka40]")
57
58 print -dpng IP2_EX6_Plot2.png
59
60 filter = (abs(u)<0.5) & (abs(v)<0.3);
61 figure(9); clf
62 imagesc(filter); axis equal; colormap gray; colorbar
63 print -dpng trash.png
64
65 Xsfiltered = Xs.*filter;
66 figure(10); clf
67 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
68 print -dpng trash.png
69
70 Xfiltered = ifftshift(Xsfiltered);
71 xfiltered = ifft2(Xfiltered);
72 figure(11); clf
73 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
74 print -dpng trash.png
75
76 title("Rectangular LPF with |u|<0.5 and |v|<0.3 [aka40]")
77
78 print -dpng IP2_EX6_Plot3.png
79
80 filter = (abs(u)<0.5) & (abs(v)<0.2);
81 figure(12); clf
82 imagesc(filter); axis equal; colormap gray; colorbar
83 print -dpng trash.png
84
85 Xsfiltered = Xs.*filter;
86 figure(13); clf
87 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
88 print -dpng trash.png
89
90 Xfiltered = ifftshift(Xsfiltered);
91 xfiltered = ifft2(Xfiltered);
92 figure(14); clf
93 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
94 print -dpng trash.png
95
96 title("Rectangular LPF with |u|<0.5 and |v|<0.2 [aka40]")
97
98 print -dpng IP2_EX6_Plot4.png
99
100 filter = (abs(u)<0.5) & (abs(v)<0.1);
101 figure(15); clf
102 imagesc(filter); axis equal; colormap gray; colorbar
103 print -dpng trash.png
104
105 Xsfiltered = Xs.*filter;
106 figure(16); clf
107 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
108 print -dpng trash.png
109
110 Xfiltered = ifftshift(Xsfiltered);
111 xfiltered = ifft2(Xfiltered);
112 figure(17); clf

```

```

113 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
114
115 title("Rectangular LPF with |u|<0.5 and |v|<0.1 [aka40]")
116
117 print -dpng IP2_EX6_Plot5.png
118
119 filter = (abs(u)<0.4) & (abs(v)<0.5);
120 figure(18); clf
121 imagesc(filter); axis equal; colormap gray; colorbar
122 print -dpng trash.png
123
124 Xsfiltered = Xs.*filter;
125 figure(19); clf
126 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
127 print -dpng trash.png
128
129 Xfiltered = ifftshift(Xsfiltered);
130 xfiltered = ifft2(Xfiltered);
131 figure(20); clf
132 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
133 print -dpng trash.png
134
135 title("Rectangular LPF with |u|<0.4 and |v|<0.5 [aka40]")
136
137 print -dpng IP2_EX6_Plot6.png
138
139
140 filter = (abs(u)<0.3) & (abs(v)<0.5);
141 figure(21); clf
142 imagesc(filter); axis equal; colormap gray; colorbar
143 print -dpng trash.png
144
145 Xsfiltered = Xs.*filter;
146 figure(22); clf
147 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
148 print -dpng trash.png
149
150 Xfiltered = ifftshift(Xsfiltered);
151 xfiltered = ifft2(Xfiltered);
152 figure(23); clf
153 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
154
155 title("Rectangular LPF with |u|<0.3 and |v|<0.5 [aka40]")
156
157 print -dpng IP2_EX6_Plot7.png
158
159 filter = (abs(u)<0.2) & (abs(v)<0.5);
160 figure(24); clf
161 imagesc(filter); axis equal; colormap gray; colorbar
162 print -dpng trash.png
163
164 Xsfiltered = Xs.*filter;
165 figure(25); clf
166 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
167 print -dpng trash.png
168
169 Xfiltered = ifftshift(Xsfiltered);

```

```

170 xfiltered = ifft2(Xfiltered);
171 figure(26); clf
172 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
173
174 title("Rectangular LPF with |u|<0.2 and |v|<0.5 [aka40]")
175
176 print -dpng IP2_EX6_Plot8.png
177
178 filter = (abs(u)<0.1) & (abs(v)<0.5);
179 figure(27); clf
180 imagesc(filter); axis equal; colormap gray; colorbar
181 print -dpng trash.png
182
183 Xsfiltered = Xs.*filter;
184 figure(28); clf
185 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
186 print -dpng trash.png
187
188 Xfiltered = ifftshift(Xsfiltered);
189 xfiltered = ifft2(Xfiltered);
190 figure(29); clf
191 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
192
193 title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")
194
195 print -dpng IP2_EX6_Plot9.png
196
197 filter = (abs(u)<0.01) & (abs(v)<0.5);
198 figure(30); clf
199 imagesc(filter); axis equal; colormap gray; colorbar
200 print -dpng trash.png
201
202 Xsfiltered = Xs.*filter;
203 figure(31); clf
204 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
205 print -dpng trash.png
206
207 Xfiltered = ifftshift(Xsfiltered);
208 xfiltered = ifft2(Xfiltered);
209 figure(32); clf
210 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
211
212 title("Rectangular LPF with |u|<0.01 and |v|<0.5 [aka40]")
213
214 print -dpng IP2_EX6_Plot10.png

```

11.6 Exercise 7

```
1 clear
2 x = zeros(399,399);
3 x(:,:)= randi(255,399);
4 figure(1); clf
5 image(x); axis equal; colormap gray; colorbar
6 print -dpng trash.png
7
8 X = fft2(x);
9 Xs = fftshift(X);
10 figure(2); clf
11 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
12 print -dpng trash.png
13
14 [rows, cols] = size(x);
15 max_size = max(rows, cols);
16 rnorm = rows/max_size; cnorm = cols/max_size;
17 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
18     linspace(-rnorm, rnorm, rows));
19 filter = (abs(u)<0.5) & (abs(v)<0.5);
20 figure(3); clf
21 imagesc(filter); axis equal; colormap gray; colorbar
22 print -dpng trash.png
23
24 Xsfiltered = Xs.*filter;
25 figure(4); clf
26 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
27 print -dpng trash.png
28
29 Xfiltered = ifftshift(Xsfiltered);
30 xfiltered = ifft2(Xfiltered);
31 figure(5); clf
32 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
33
34 title("Rectangular LPF with |u|<0.5 and |v|<0.5 [aka40]")
35
36 print -dpng IP2_EX7_Plot1.png
37
38
39 filter = (abs(u)<0.1) & (abs(v)<0.5);
40 figure(6); clf
41 imagesc(filter); axis equal; colormap gray; colorbar
42 print -dpng trash.png
43
44 Xsfiltered = Xs.*filter;
45 figure(7); clf
46 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
47 print -dpng trash.png
48
49 Xfiltered = ifftshift(Xsfiltered);
50 xfiltered = ifft2(Xfiltered);
51 figure(8); clf
52 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
53
54 title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")
55
```

```

56 print -dpng IP2_EX7_Plot2.png
57
58 filter = (abs(u)<0.1) & (abs(v)<0.5);
59 figure(9); clf
60 imagesc(filter); axis equal; colormap gray; colorbar
61 print -dpng trash.png
62
63 Xsfiltered = Xs.*filter;
64 figure(10); clf
65 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
66 print -dpng trash.png
67
68 Xfiltered = ifftshift(Xsfiltered);
69 xfiltered = ifft2(Xfiltered);
70 figure(11); clf
71 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
72
73 title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")
74
75 print -dpng IP2_EX7_Plot3.png
76
77 filter = (abs(u)<0.1) & (abs(v)<0.1);
78 figure(12); clf
79 imagesc(filter); axis equal; colormap gray; colorbar
80 print -dpng trash.png
81
82 Xsfiltered = Xs.*filter;
83 figure(13); clf
84 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
85 print -dpng trash.png
86
87 Xfiltered = ifftshift(Xsfiltered);
88 xfiltered = ifft2(Xfiltered);
89 figure(14); clf
90 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
91
92 title("Rectangular LPF with |u|<0.1 and |v|<0.1 [aka40]")
93
94 print -dpng IP2_EX7_Plot4.png

```

11.7 Exercise 8

```
1 clear
2 x = zeros(399,399);
3 x(:,:)= randi(255,399);
4 figure(1); clf
5 image(x); axis equal; colormap gray; colorbar
6 print -dpng trash.png
7
8 X = fft2(x);
9 Xs = fftshift(X);
10 figure(2); clf
11 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
12 print -dpng trash.png
13
14 [rows, cols] = size(x);
15 max_size = max(rows, cols);
16 rnorm = rows/max_size; cnorm = cols/max_size;
17 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
18     linspace(-rnorm, rnorm, rows));
19 filter = (abs(u)<0.006) & (abs(v)<0.006);
20 figure(3); clf
21 imagesc(filter); axis equal; colormap gray; colorbar
22 print -dpng trash.png
23
24 Xsfiltered = Xs.*filter;
25 figure(4); clf
26 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
27 print -dpng trash.png
28
29 Xfiltered = ifftshift(Xsfiltered);
30 xfiltered = ifft2(Xfiltered);
31 figure(5); clf
32 filter = (abs(u)<0.006) & (abs(v)<0.006);
33 figure(3); clf
34 imagesc(filter); axis equal; colormap gray; colorbar
35 print -dpng trash.png
36
37 Xsfiltered = Xs.*filter;
38 figure(4); clf
39 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
40 print -dpng trash.png
41
42 Xfiltered = ifftshift(Xsfiltered);
43 xfiltered = ifft2(Xfiltered);
44 figure(5); clf
45 imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
46
47 title("Rectangular LPF with |u|<0.006 and |v|<0.006 [aka40]")
48
49 print -dpng IP2_EX8_Plot1.png
50
51 figure(6); clf
52 imagesc(xfiltered); axis equal; colormap gray; colorbar
53
54 title("Rectangular LPF with |u|<0.006 and |v|<0.006 no Scaling [aka40]")
55
```

```
56 print -dpng IP2_EX8_Plot6.png
57
58
59 figure(7); clf
60 surf(xfiltered); colormap gray; shading interp; colorbar
61 title("Rectangular LPF with |u|<0.006 and |v|<0.006 no Scaling [aka40]")
62
63 print -dpng IP2_EX8_Plot7.png
```

11.8 Exercise 9

```
1 x = imread('coins.png');
2 x = x(2:end, 2:end);
3 figure(1); clf
4 image(x); axis equal; colormap gray; colorbar
5 print -dpng trash.png
6
7 X = fft2(x);
8 Xs = fftshift(X);
9 figure(2); clf
10 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
11 print -dpng trash.png
12
13 [rows, cols] = size(x);
14 max_size = max(rows, cols);
15 rnorm = rows/max_size; cnorm = cols/max_size;
16 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
17     linspace(-rnorm, rnorm, rows));
18 filter = (abs(u)>0.1) | (abs(v)>0.1);
19 figure(3); clf
20 imagesc(filter); axis equal; colormap gray; colorbar
21 print -dpng trash.png
22
23 Xsfiltered = Xs.*filter;
24 figure(4); clf
25 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
26 print -dpng trash.png
27
28 Xfiltered = ifftshift(Xsfiltered);
29 xfiltered = ifft2(Xfiltered);
30 figure(5); clf
31 imagesc(xfiltered); axis equal; colormap gray; colorbar
32 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.1");
33 print -dpng IP2_EX9_Plot1.png
34
35
36 filter = (abs(u)>0.3) | (abs(v)>0.1);
37 figure(6); clf
38 imagesc(filter); axis equal; colormap gray; colorbar
39 print -dpng trash.png
40
41 Xsfiltered = Xs.*filter;
42 figure(7); clf
43 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
44 print -dpng trash.png
45
46 Xfiltered = ifftshift(Xsfiltered);
47 xfiltered = ifft2(Xfiltered);
48 figure(8); clf
49 imagesc(xfiltered); axis equal; colormap gray; colorbar
50 title("Rectangular HPF with abs(u)>0.3 and abs(v)>0.1");
51 print -dpng IP2_EX9_Plot2.png
52
53 filter = (abs(u)>0.5) | (abs(v)>0.1);
54 figure(9); clf
55 imagesc(filter); axis equal; colormap gray; colorbar
```

```

56 print -dpng trash.png
57
58 Xsfiltered = Xs.*filter;
59 figure(10); clf
60 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
61 print -dpng trash.png
62
63 Xfiltered = ifftshift(Xsfiltered);
64 xfiltered = ifft2(Xfiltered);
65 figure(11); clf
66 imagesc(xfiltered); axis equal; colormap gray; colorbar
67 title("Rectangular HPF with abs(u)>0.5 and abs(v)>0.1");
68 print -dpng IP2_EX9_Plot3.png
69
70 filter = (abs(u)>0.7) | (abs(v)>0.1);
71 figure(12); clf
72 imagesc(filter); axis equal; colormap gray; colorbar
73 print -dpng trash.png
74
75 Xsfiltered = Xs.*filter;
76 figure(13); clf
77 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
78 print -dpng trash.png
79
80 Xfiltered = ifftshift(Xsfiltered);
81 xfiltered = ifft2(Xfiltered);
82 figure(14); clf
83 imagesc(xfiltered); axis equal; colormap gray; colorbar
84 title("Rectangular HPF with abs(u)>0.7 and abs(v)>0.1");
85 print -dpng IP2_EX9_Plot4.png
86
87 filter = (abs(u)>0.9) | (abs(v)>0.1);
88 figure(15); clf
89 imagesc(filter); axis equal; colormap gray; colorbar
90 print -dpng trash.png
91
92 Xsfiltered = Xs.*filter;
93 figure(16); clf
94 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
95 print -dpng trash.png
96
97 Xfiltered = ifftshift(Xsfiltered);
98 xfiltered = ifft2(Xfiltered);
99 figure(17); clf
100 imagesc(xfiltered); axis equal; colormap gray; colorbar
101 title("Rectangular HPF with abs(u)>0.9 and abs(v)>0.1");
102 print -dpng IP2_EX9_Plot5.png
103
104 filter = (abs(u)>1.1) | (abs(v)>0.1);
105 figure(18); clf
106 imagesc(filter); axis equal; colormap gray; colorbar
107 print -dpng trash.png
108
109 Xsfiltered = Xs.*filter;
110 figure(19); clf
111 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
112 print -dpng trash.png

```

```

113 Xfiltered = ifftshift(Xsfiltered);
114 xfiltered = ifft2(Xfiltered);
115 figure(20); clf
116 imagesc(xfiltered); axis equal; colormap gray; colorbar
117 title("Rectangular HPF with abs(u)>1.1 and abs(v)>0.1");
118 print -dpng IP2_EX9_Plot6.png
119
120
121 filter = (abs(u)>0.1) | (abs(v)>0.3);
122 figure(21); clf
123 imagesc(filter); axis equal; colormap gray; colorbar
124 print -dpng trash.png
125
126 Xsfiltered = Xs.*filter;
127 figure(22); clf
128 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
129 print -dpng trash.png
130
131 Xfiltered = ifftshift(Xsfiltered);
132 xfiltered = ifft2(Xfiltered);
133 figure(23); clf
134 imagesc(xfiltered); axis equal; colormap gray; colorbar
135 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.3");
136 print -dpng IP2_EX9_Plot7.png
137
138 filter = (abs(u)>0.1) | (abs(v)>0.5);
139 figure(24); clf
140 imagesc(filter); axis equal; colormap gray; colorbar
141 print -dpng trash.png
142
143 Xsfiltered = Xs.*filter;
144 figure(25); clf
145 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
146 print -dpng trash.png
147
148 Xfiltered = ifftshift(Xsfiltered);
149 xfiltered = ifft2(Xfiltered);
150 figure(26); clf
151 imagesc(xfiltered); axis equal; colormap gray; colorbar
152 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.5");
153 print -dpng IP2_EX9_Plot8.png
154
155 filter = (abs(u)>0.1) | (abs(v)>0.7);
156 figure(27); clf
157 imagesc(filter); axis equal; colormap gray; colorbar
158 print -dpng trash.png
159
160 Xsfiltered = Xs.*filter;
161 figure(28); clf
162 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
163 print -dpng trash.png
164
165 Xfiltered = ifftshift(Xsfiltered);
166 xfiltered = ifft2(Xfiltered);
167 figure(29); clf
168 imagesc(xfiltered); axis equal; colormap gray; colorbar
169 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.7");

```

```

170 print -dpng IP2_EX9_Plot9.png
171
172 filter = (abs(u)>0.1) | (abs(v)>0.9);
173 figure(30); clf
174 imagesc(filter); axis equal; colormap gray; colorbar
175 print -dpng trash.png
176
177 Xsfiltered = Xs.*filter;
178 figure(31); clf
179 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
180 print -dpng trash.png
181
182 Xfiltered = ifftshift(Xsfiltered);
183 xfiltered = ifft2(Xfiltered);
184 figure(32); clf
185 imagesc(xfiltered); axis equal; colormap gray; colorbar
186 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.9");
187 print -dpng IP2_EX9_Plot10.png
188
189 filter = (abs(u)>0.1) | (abs(v)>0.9);
190 figure(33); clf
191 imagesc(filter); axis equal; colormap gray; colorbar
192 print -dpng trash.png
193
194 Xsfiltered = Xs.*filter;
195 figure(34); clf
196 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
197 print -dpng trash.png
198
199 Xfiltered = ifftshift(Xsfiltered);
200 xfiltered = ifft2(Xfiltered);
201 figure(35); clf
202 imagesc(xfiltered); axis equal; colormap gray; colorbar
203 title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.9");
204 print -dpng IP2_EX9_Plot11.png

```

11.9 Exercise 10

```
1 clear
2 x = imread('coins.png');
3 x = x(2:end, 2:end);
4 figure(1); clf
5 image(x); axis equal; colormap gray; colorbar
6 print -dpng trash.png
7
8 X = fft2(x);
9 Xs = fftshift(X);
10 figure(2); clf
11 imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
12 print -dpng trash.png
13
14
15 [rows, cols] = size(x);
16 max_size = max(rows, cols);
17 rnorm = rows/max_size; cnorm = cols/max_size;
18 [v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
19    linspace(-rnorm, rnorm, rows));
20 HPF = (abs(u)>0.2) | (abs(v)>0.3);
21 LPF = (abs(u)<0.4) & (abs(v)<0.5);
22 filter = HPF.*LPF;
23 figure(3); clf
24 imagesc(filter); axis equal; colormap gray; colorbar
25 title("Bandwidth Filter Image [aka40]");
26 print -dpng IP2_EX10_Plot1.png
27
28 Xsfiltered = Xs.*filter;
29 figure(4); clf
30 imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
31 title("Bandwidth Filter FFT Image [aka40]");
32 print -dpng IP2_EX10_Plot2.png
33
34 Xfiltered = ifftshift(Xsfiltered);
35 xfiltered = ifft2(Xfiltered);
36 figure(5); clf
37 imagesc(xfiltered); axis equal; colormap gray; colorbar
38 title("Bandwidth filter with 0.2<abs(u)<0.3 and 0.3<abs(v)<0.5");
39 print -dpng IP2_EX10_Plot3.png
```