ECE 280L – Spring 2021

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 abs(u) decreases (i.e. the height of the rectangular LPF filter decreases) vertical blurring in the image increases. As the limit of the 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 abs(u) decreases vertical blurring in the image increases. As the limit of the abs(v) decreases (i.e. the width of the rectangular LPF filter decreases) horizontal blurring in the image increases. When the limits of both abs(u) and 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

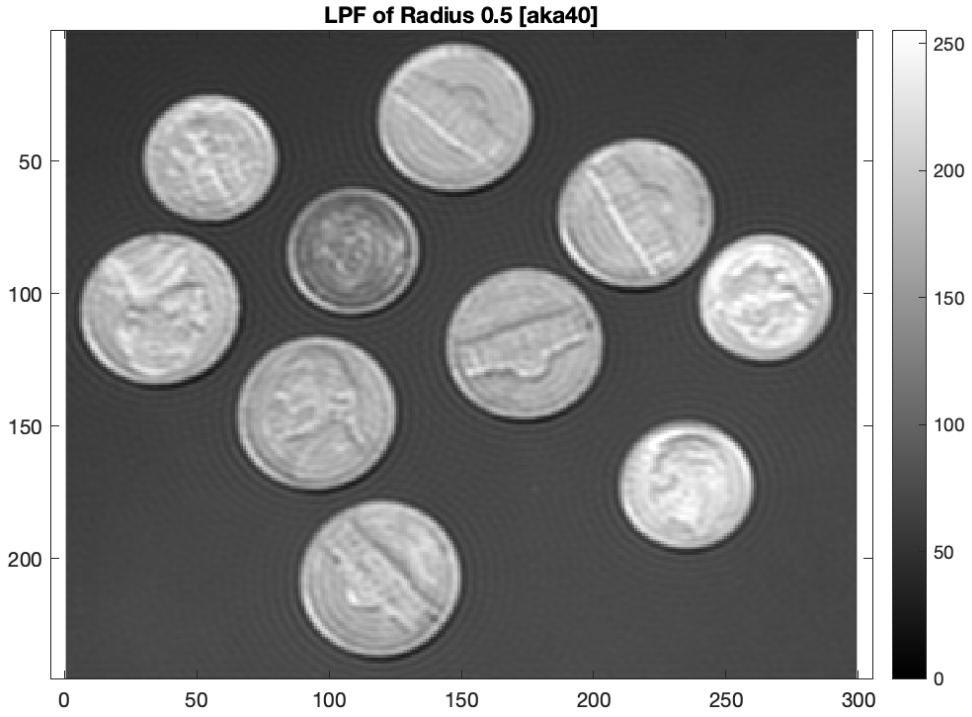
As the minimum of the abs(u) increases (i.e. the height of the rectangular HPF filter increases) vertical blurring in the image decreases. As the minumum of the abs(v) increases (i.e. the width of the rectangular HPF filter increases) horizontal blurring in the image decreases.

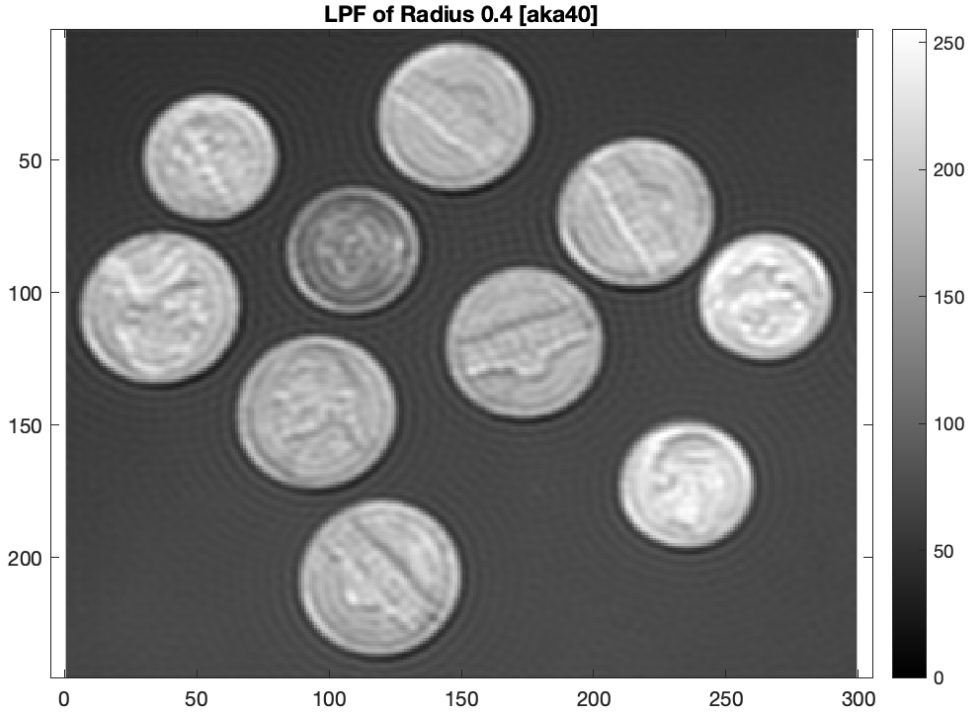
9 Exercise 10

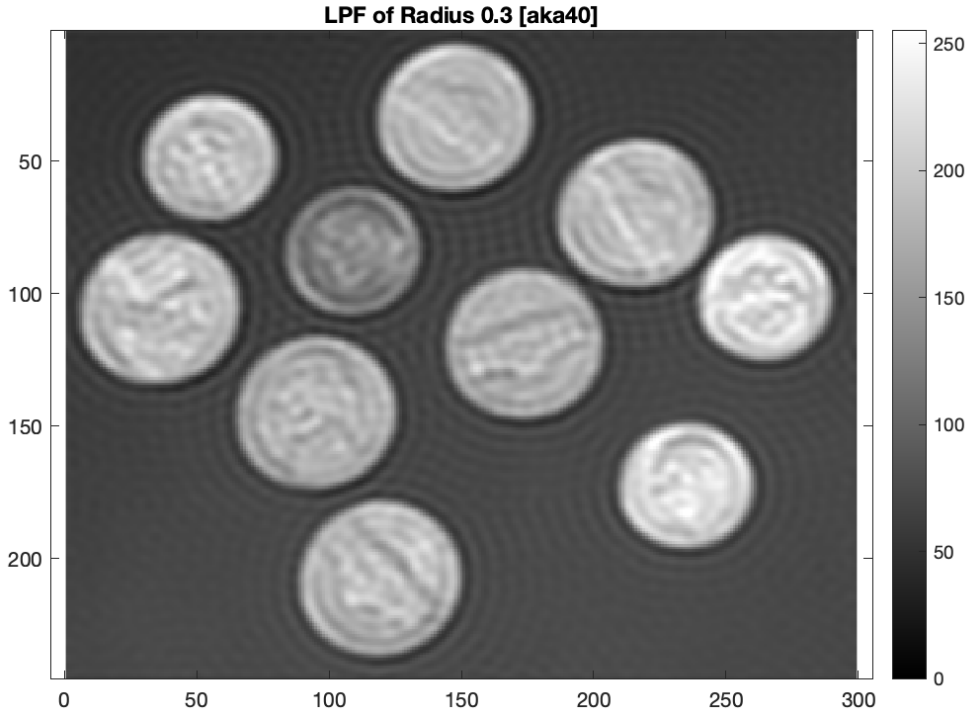
The higher the range of abs(u) (i.e. the smaller the height of the inner white portion of the rectangular BPF) the lower the vertical blur. The higher the range of abs(v) (i.e. the smaller the width of the inner white portion of the rectangular BPF) the lower the horizontal blur.

10 Graphs

10.1 Exercise 3






LPF of Radius 0.3 [aka40]
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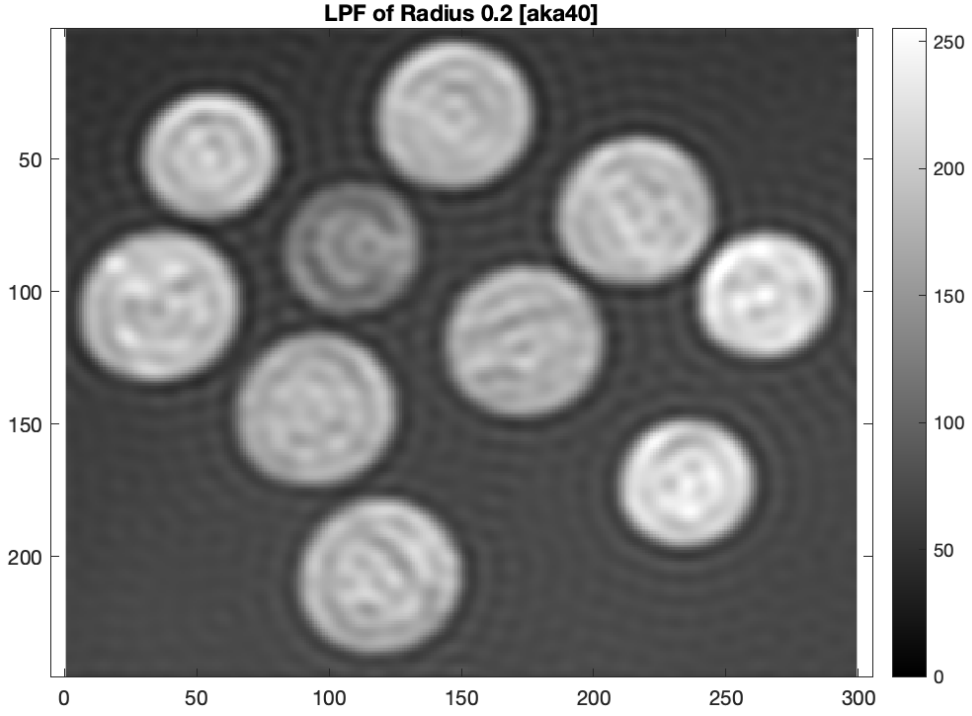
50
0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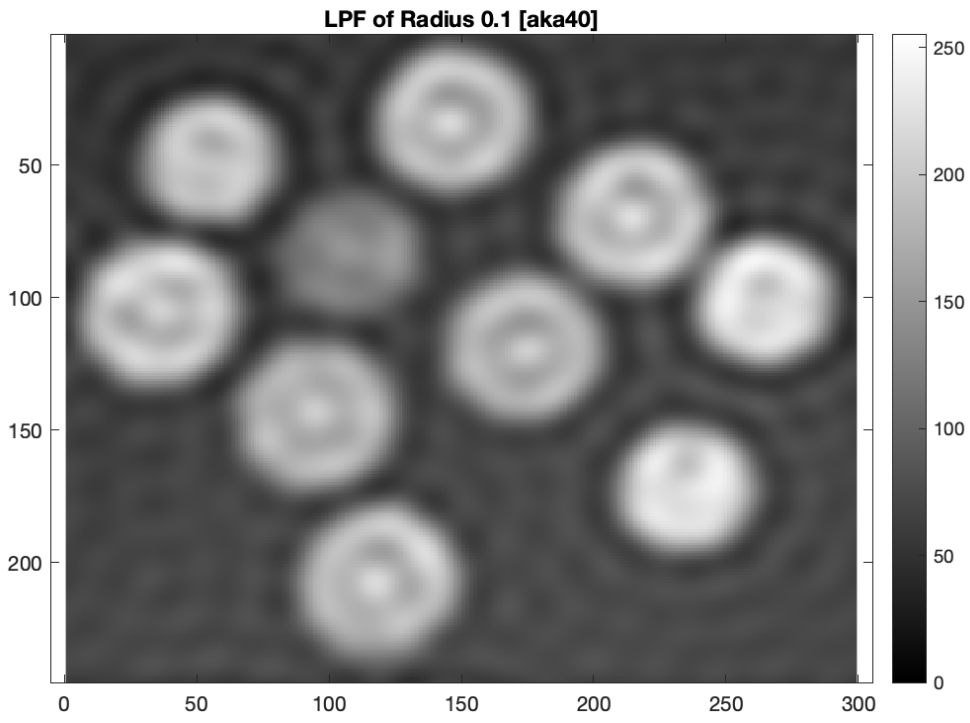
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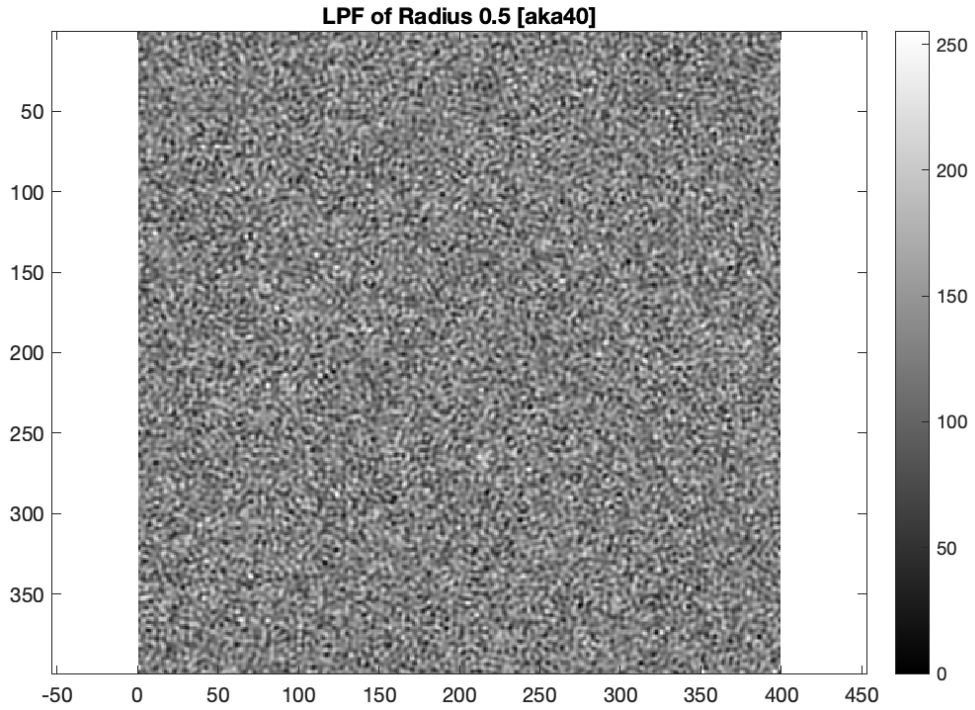
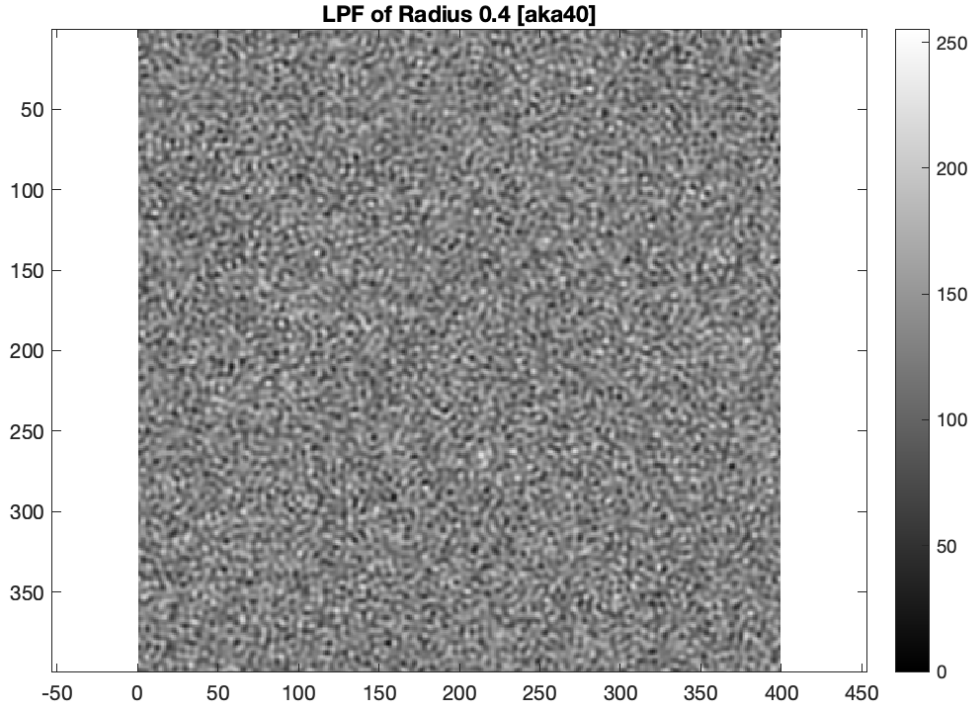
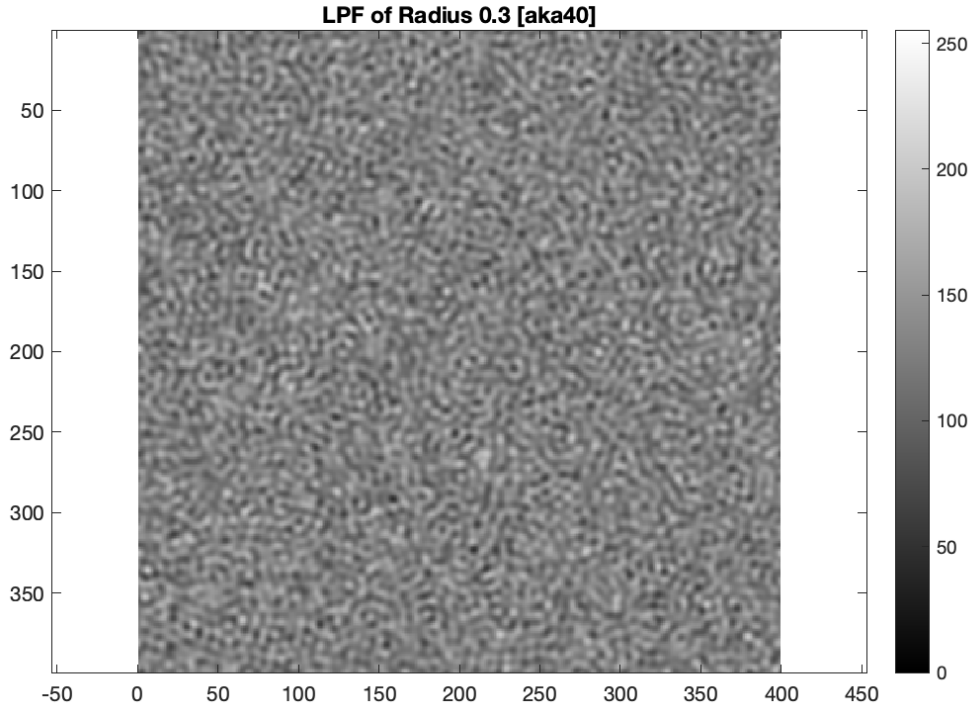
100
50
0

10.2 Exercise 4






LPF of Radius 0.3 [aka40]
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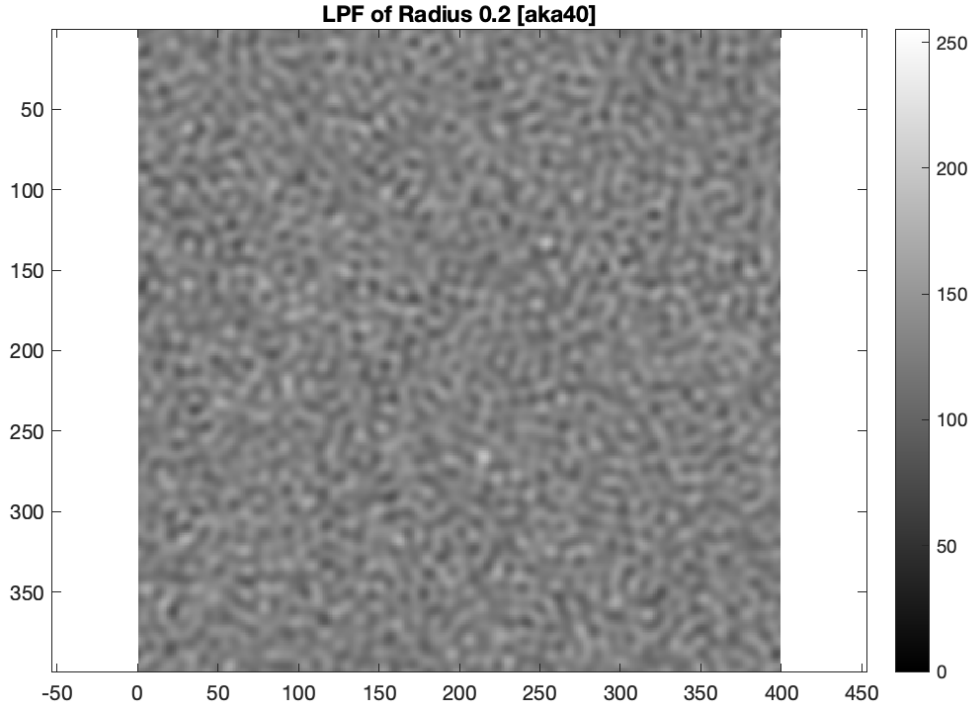
150
100
50
0


LPF of Radius 0.2 [aka40]
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100
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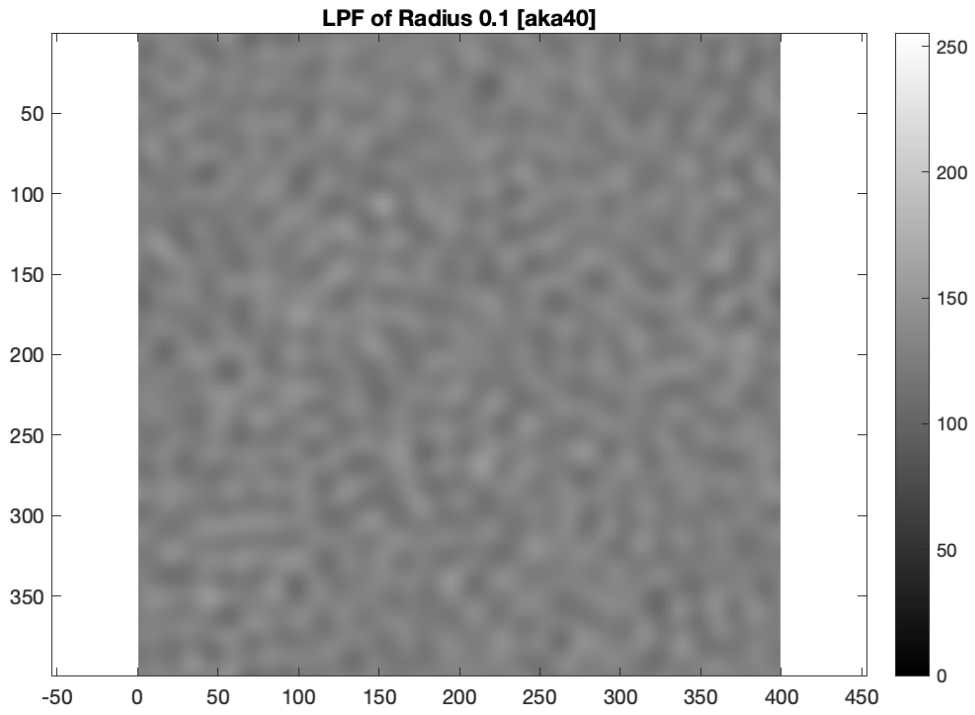
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150
100
50
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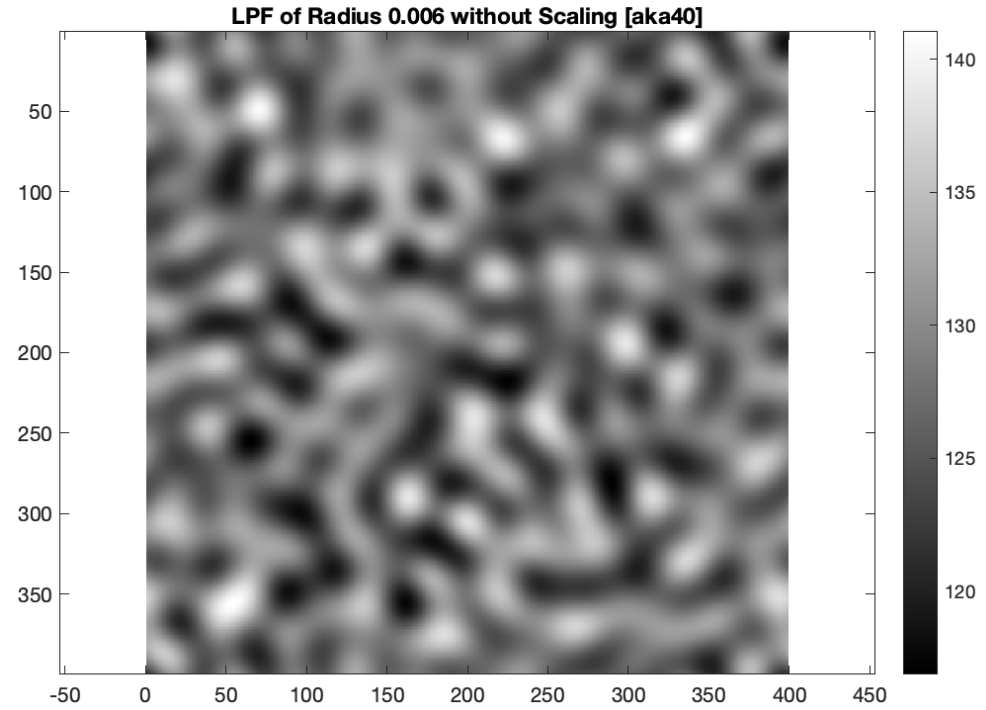
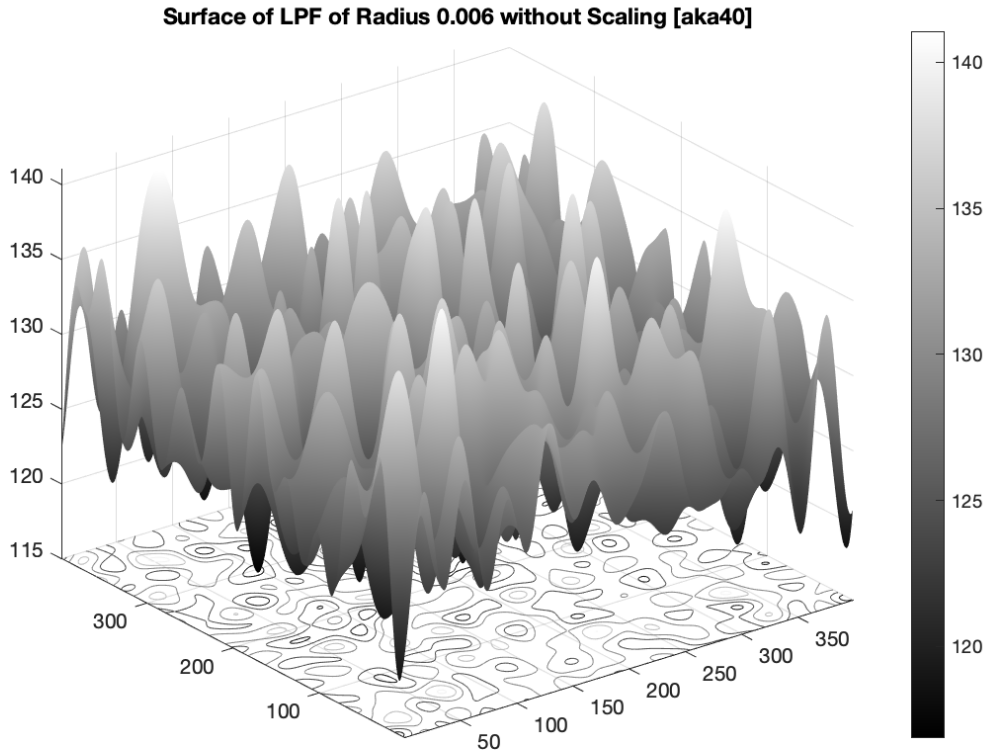
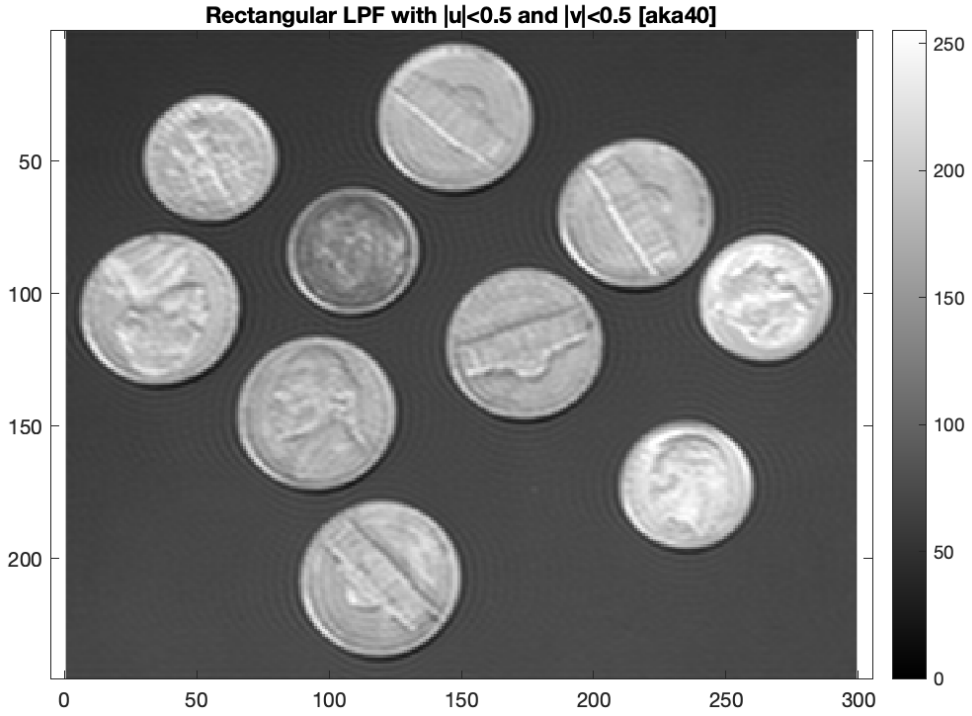
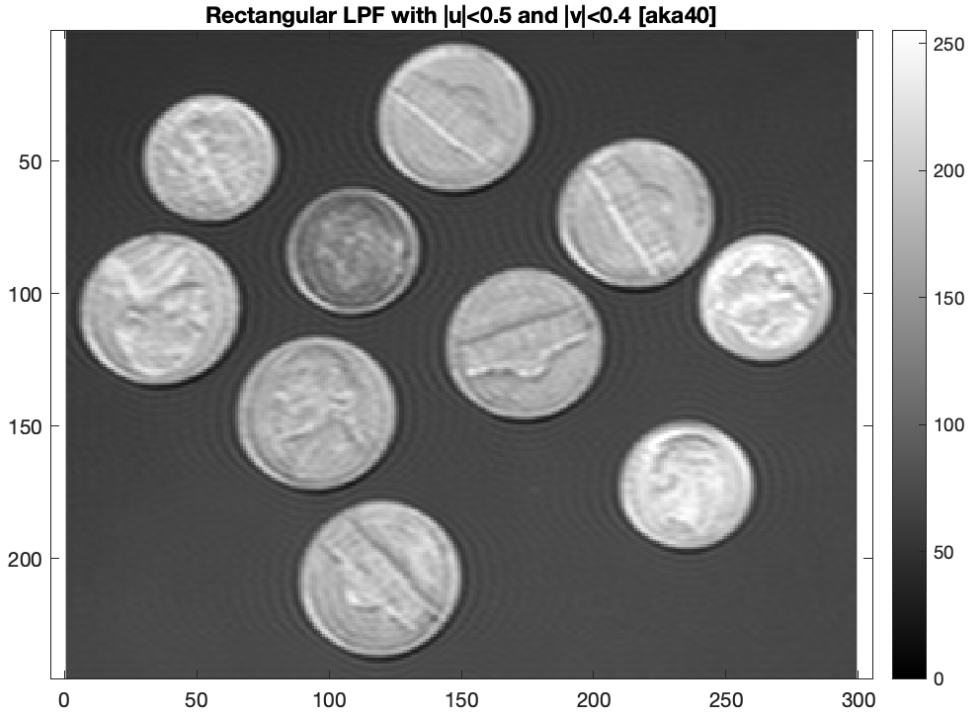
10.3 Exercise 5

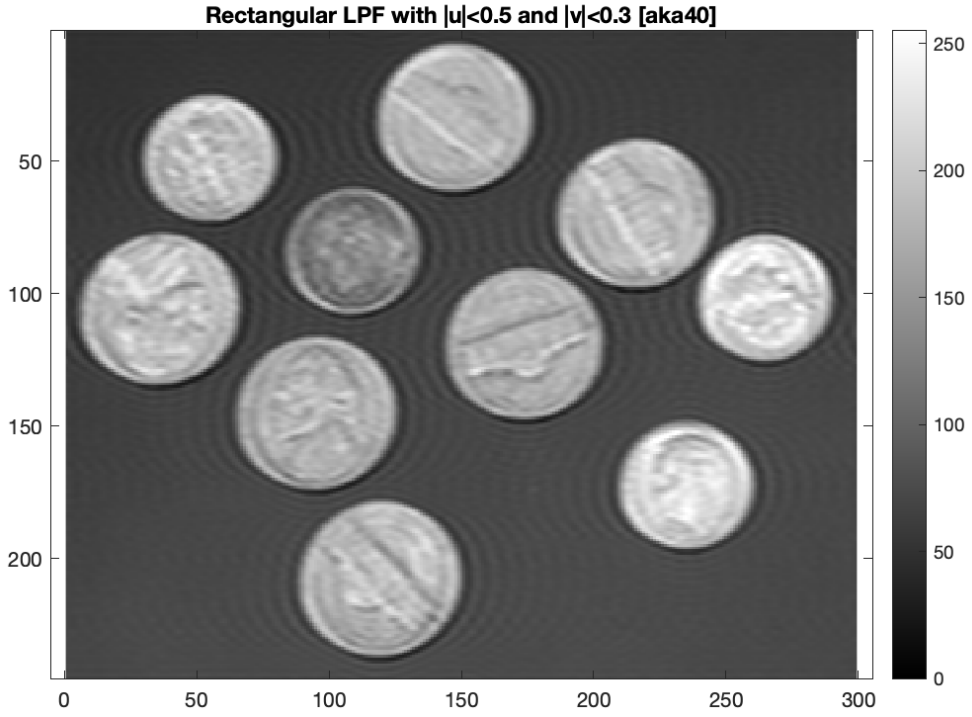




10.4 Exercise 6



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300
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100
50
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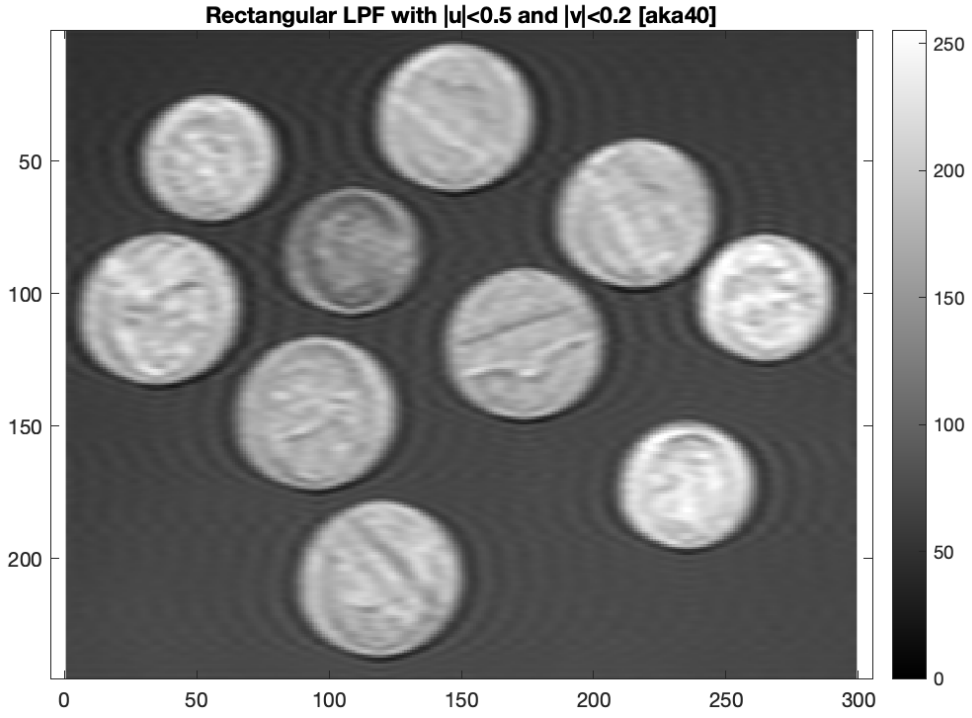
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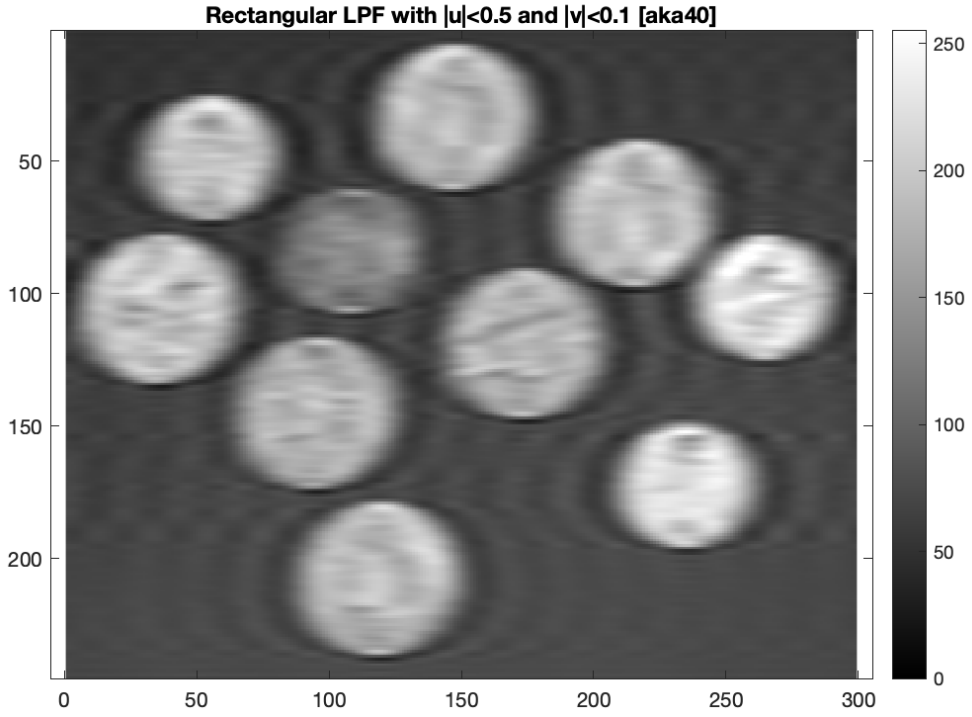
100
150
200
250
300
250
200
150
100
50
0


Rectangular LPF with |u|<0.5 and |v|<0.1 [aka40]
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300
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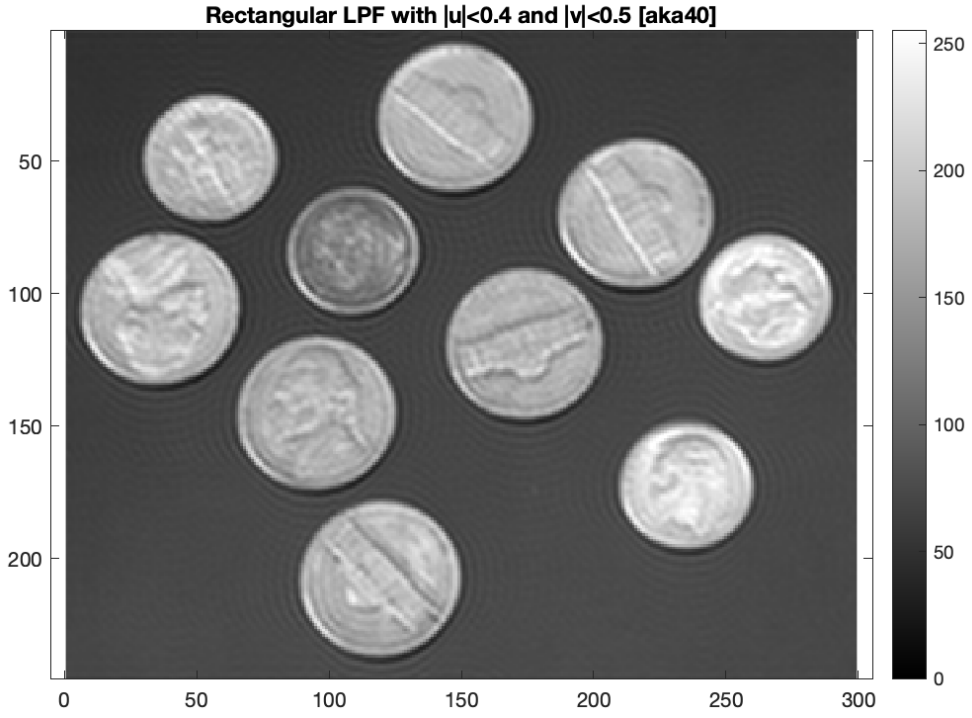
100
50
0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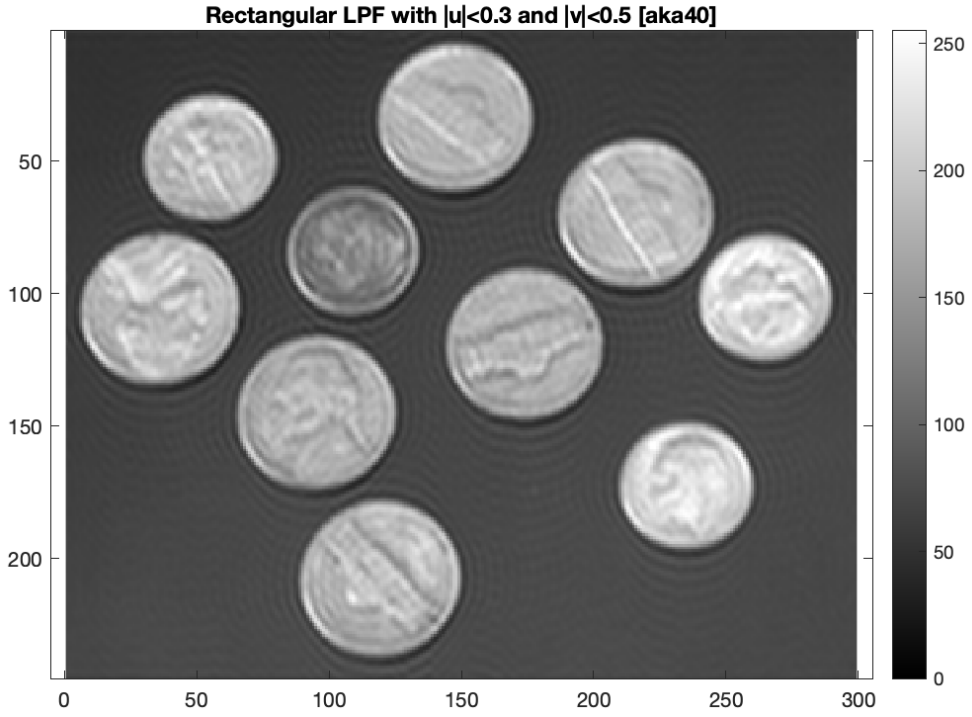
200
150
100
50
0


Rectangular LPF with |u|<0.3 and |v|<0.5 [aka40]
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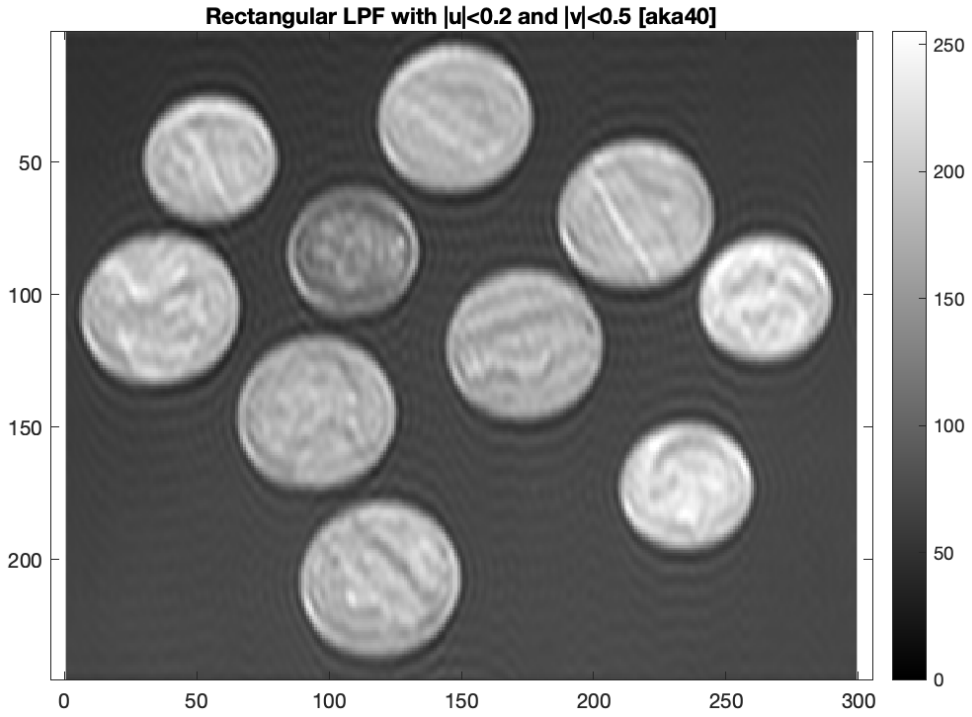
100
150
200
0
50
100
150
200
250
300
250
200
150
100
50
0


Rectangular LPF with |u|<0.2 and |v|<0.5 [aka40]
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150
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250
300
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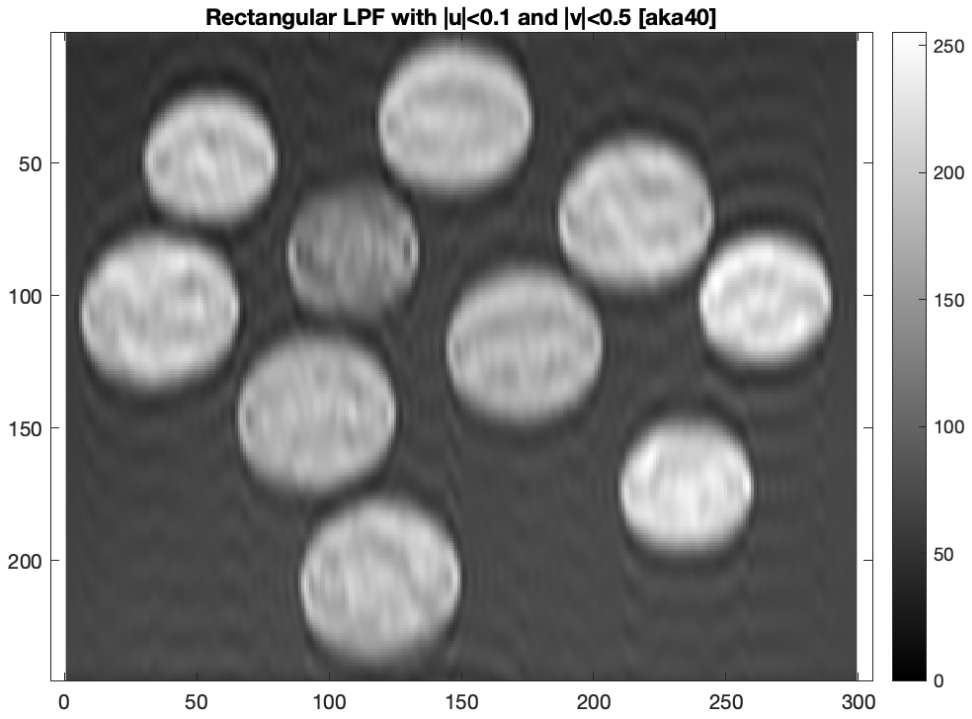
150
100
50
0


Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]
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150
200
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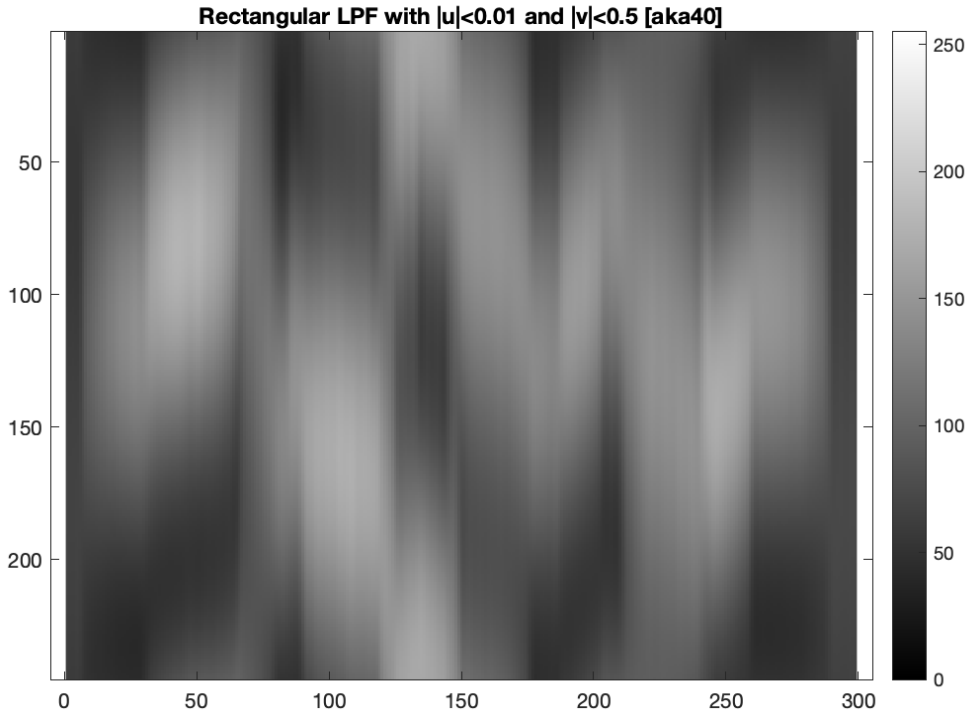
Rectangular LPF with |u|<0.01 and |v|<0.5 [aka40]
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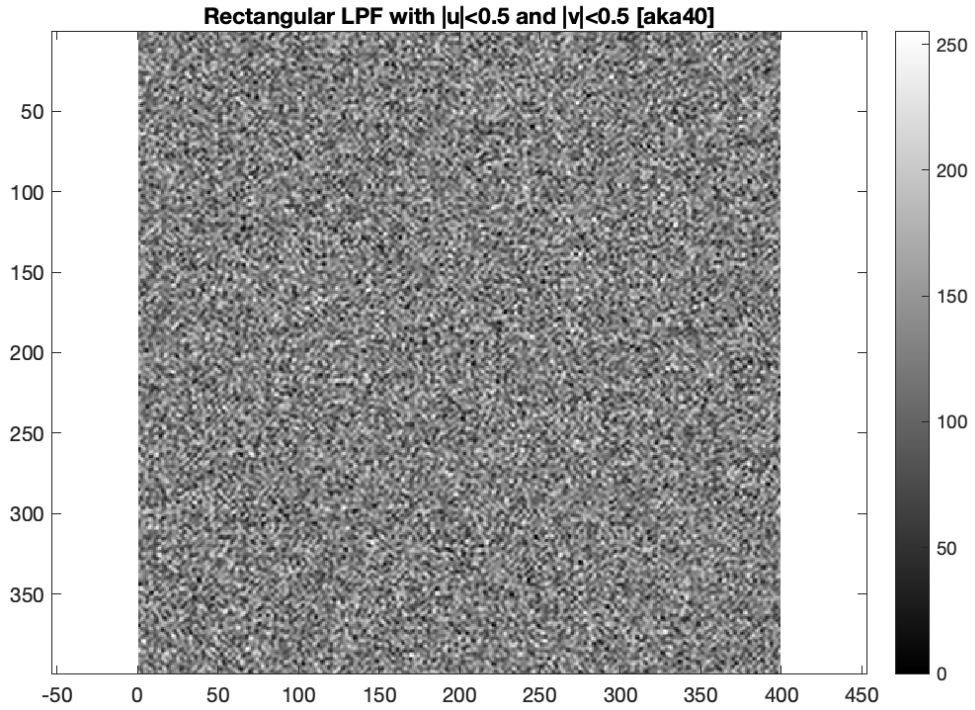
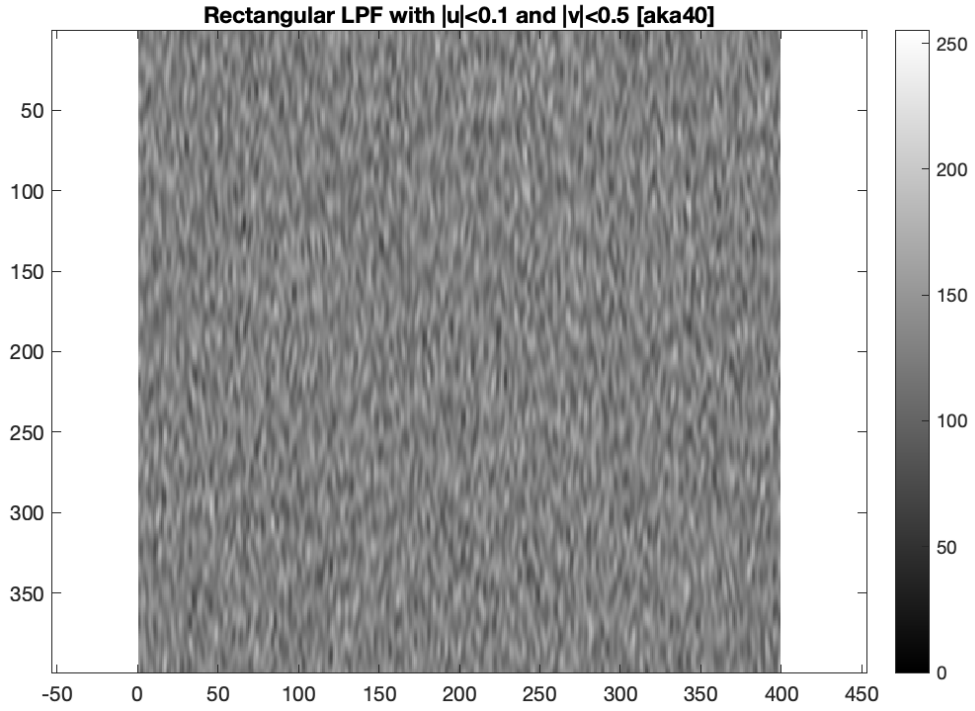
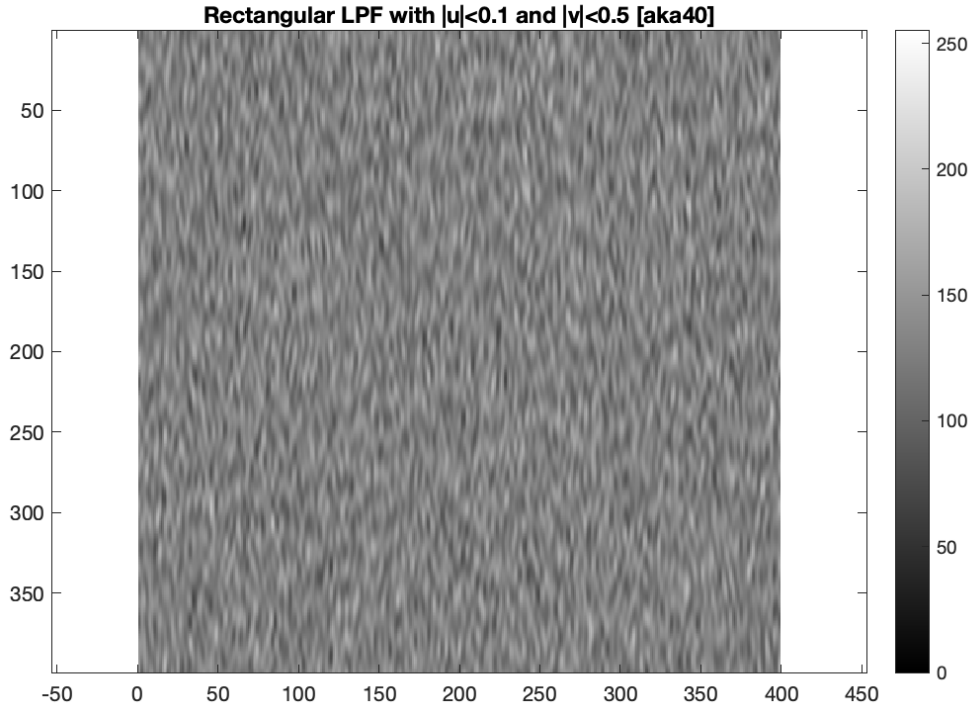
100
50
0

10.5 Exercise 7






Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]
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100
150
200
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300
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400
450
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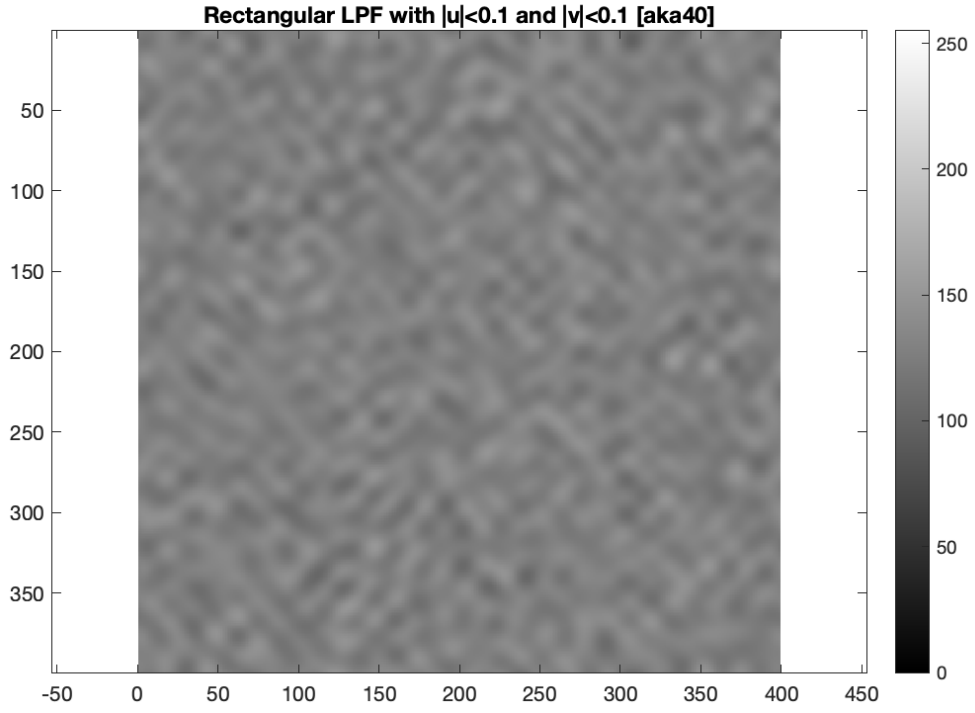
50
0


Rectangular LPF with |u|<0.1 and |v|<0.1 [aka40]
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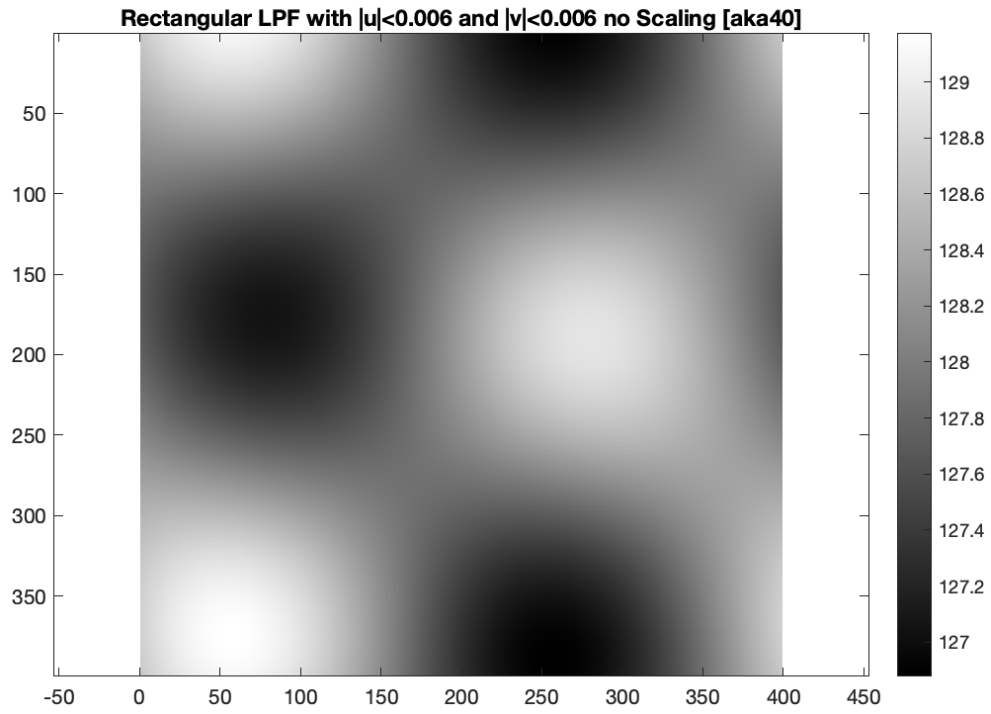
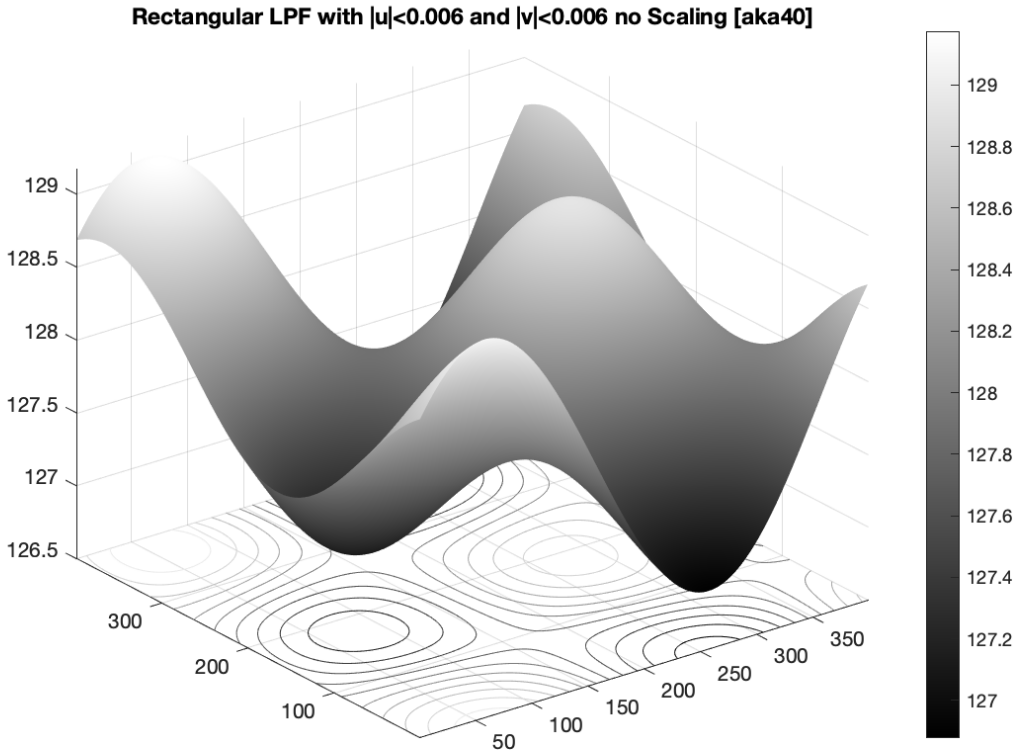
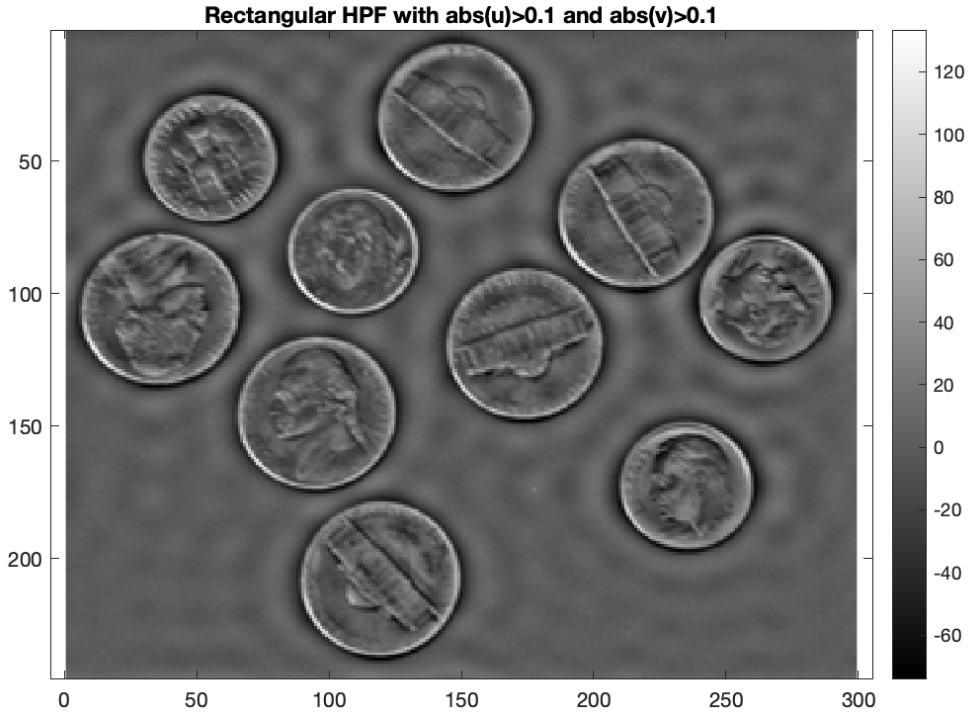
200
150
100
50
0

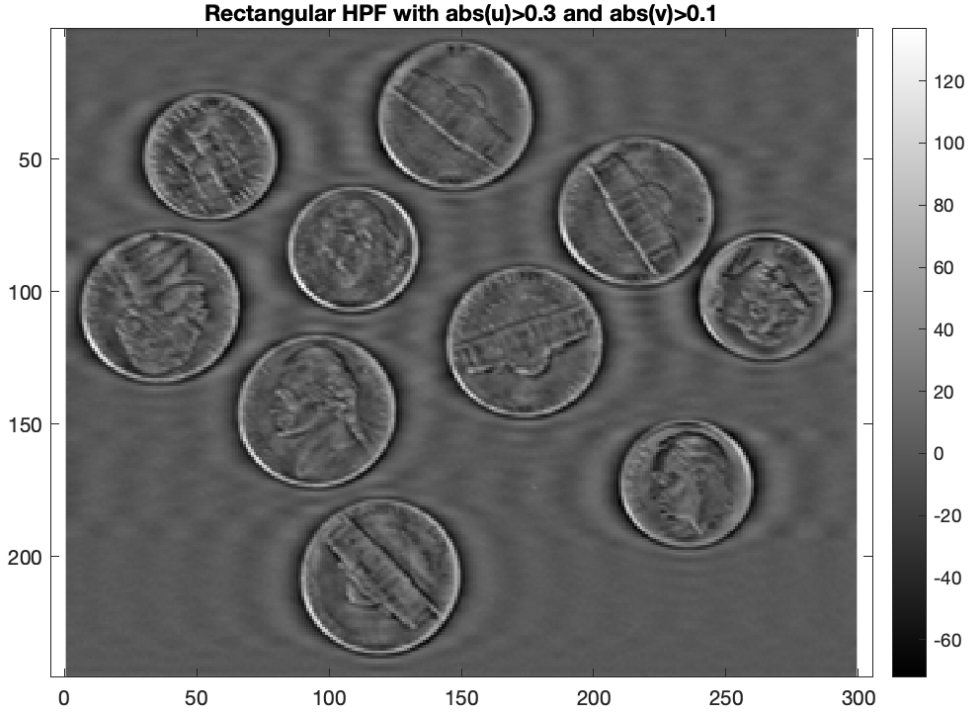
10.6 Exercise 8

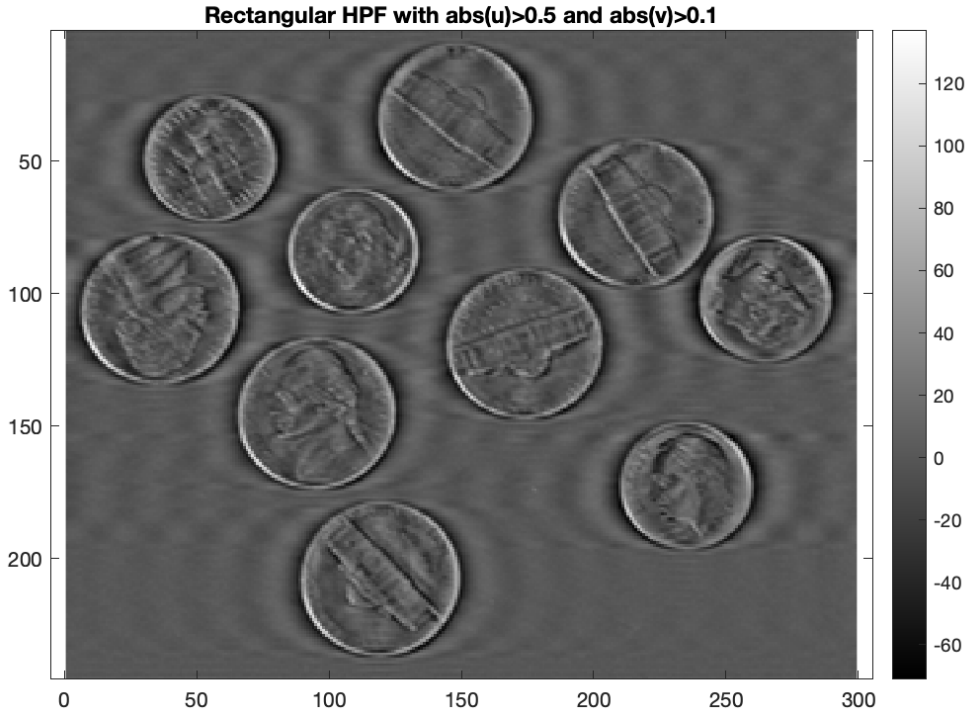




10.7 Exercise 9






Rectangular HPF with abs(u)>0.5 and abs(v)>0.1
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100
150
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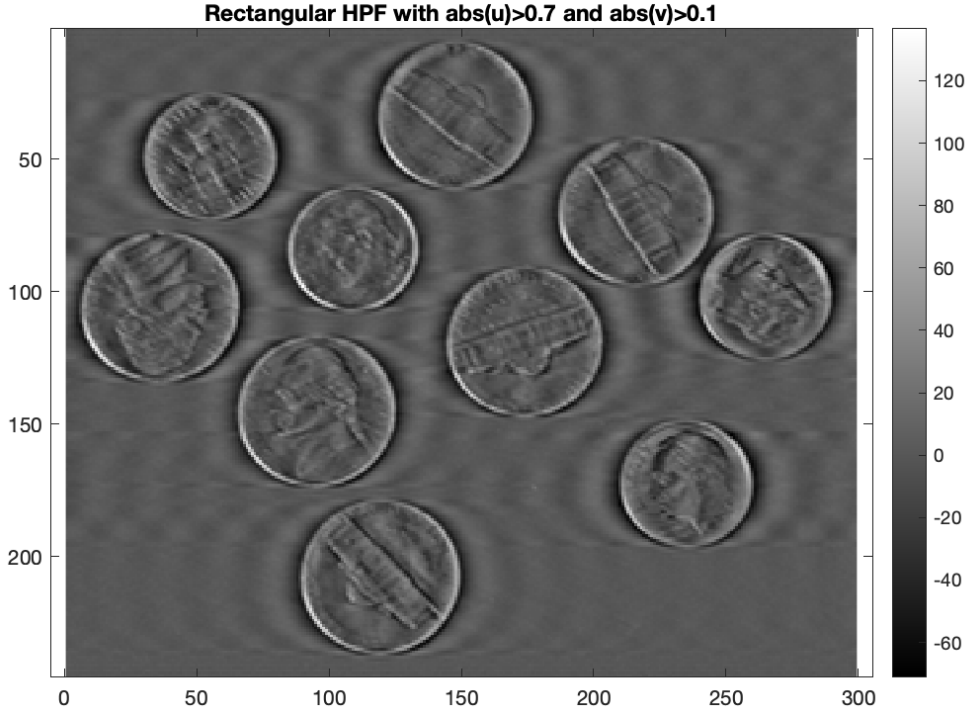
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.7 and abs(v)>0.1
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100
150
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150
200
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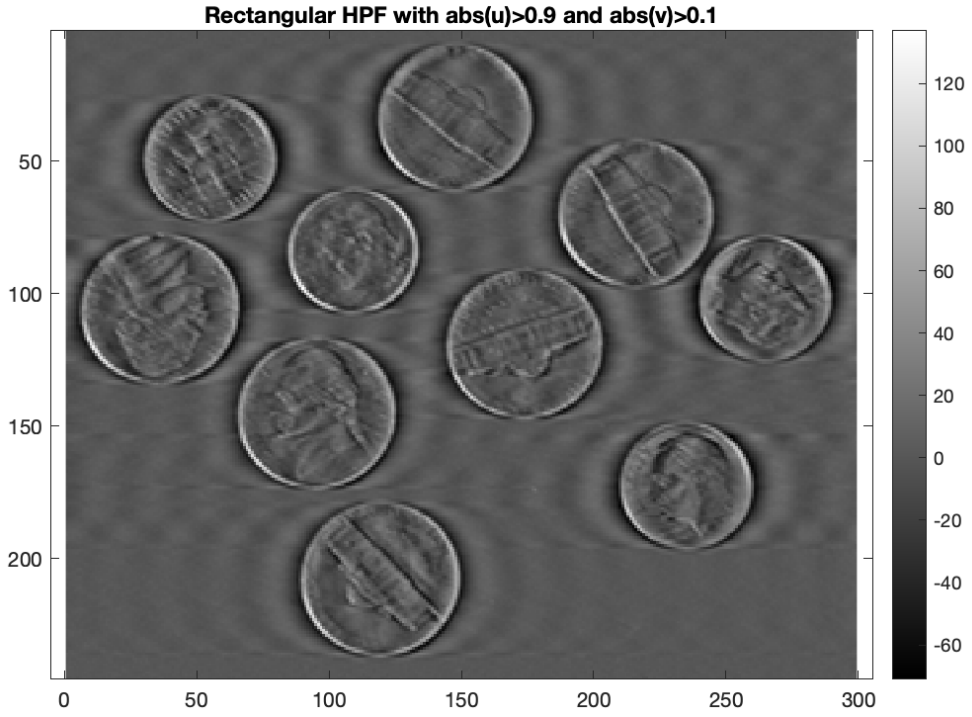
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.9 and abs(v)>0.1
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100
150
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0
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100
150
200
250
300
120
100
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60
40
20
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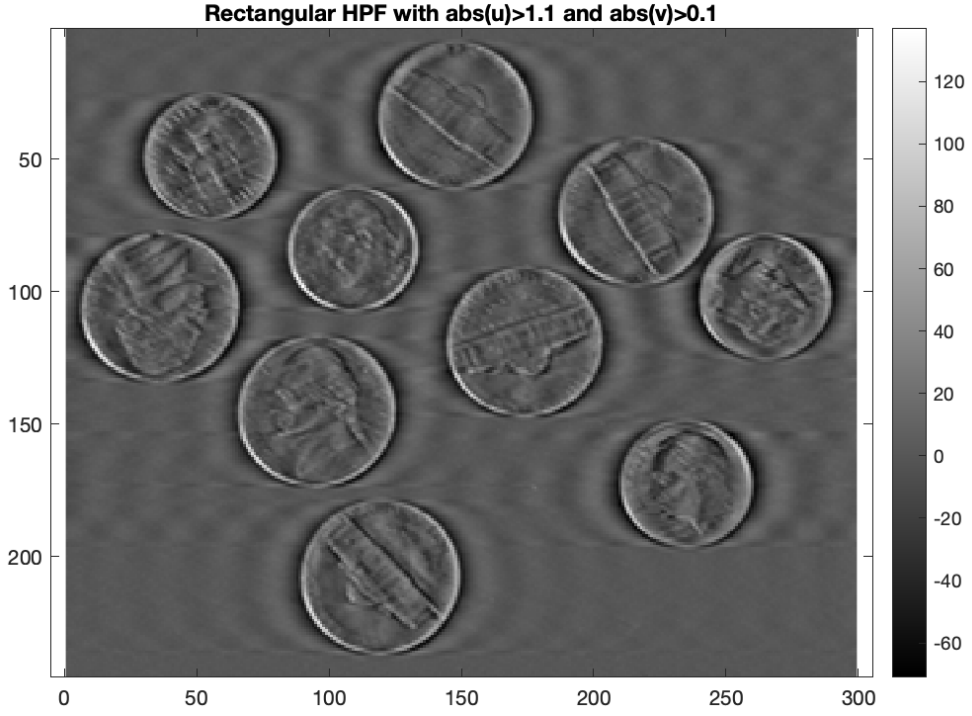
-20
-40
-60


Rectangular HPF with abs(u)>1.1 and abs(v)>0.1
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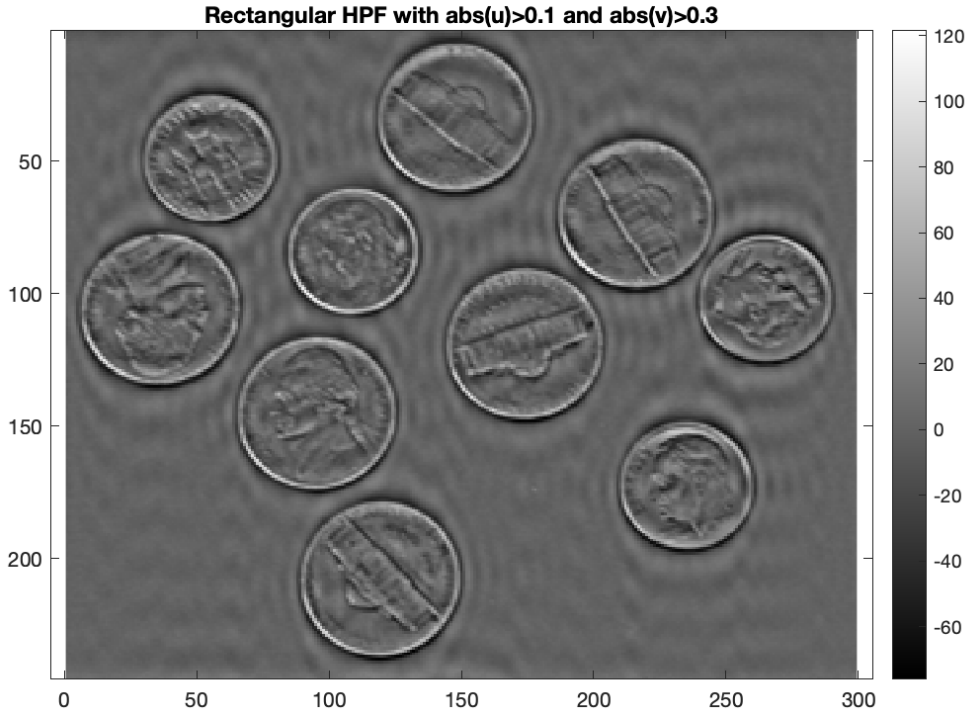
100
150
200
0
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.1 and abs(v)>0.3
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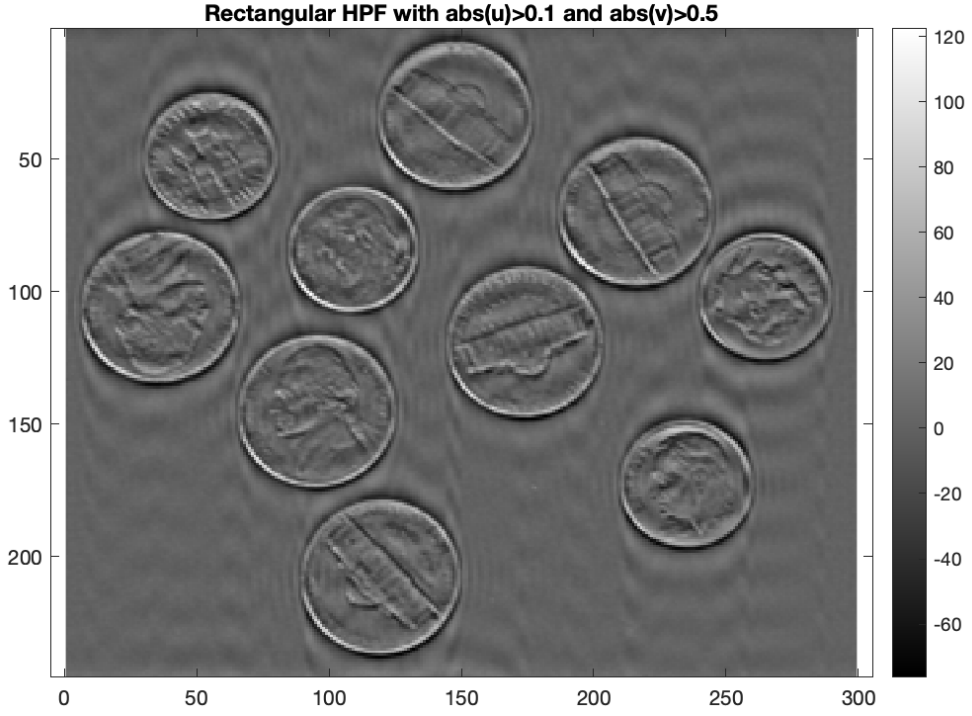
100
150
200
0
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.1 and abs(v)>0.5
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100
150
200
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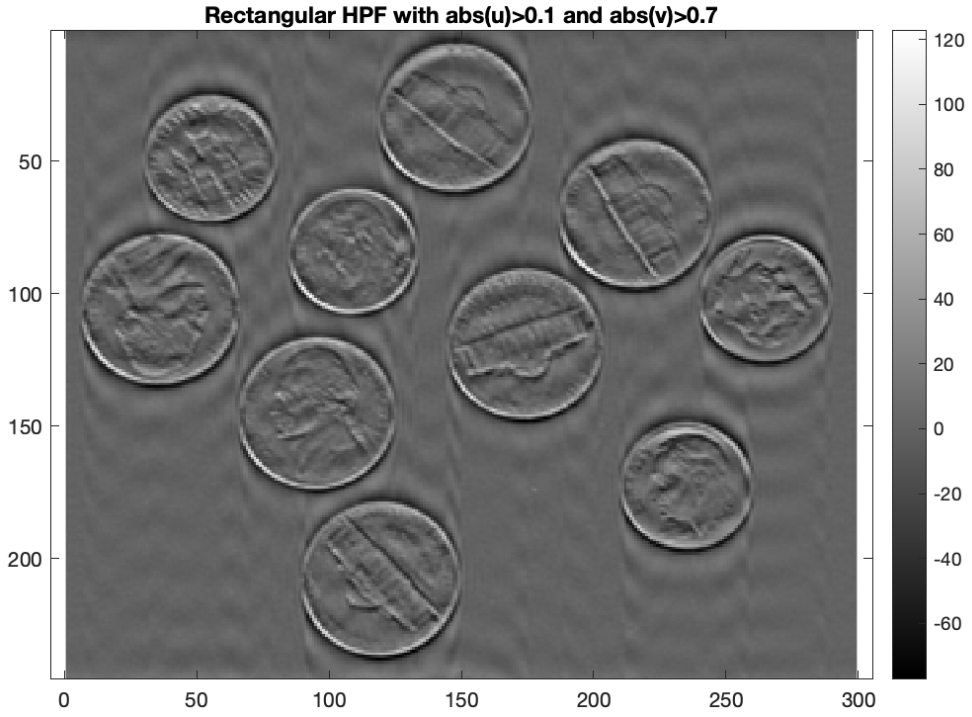
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.1 and abs(v)>0.7
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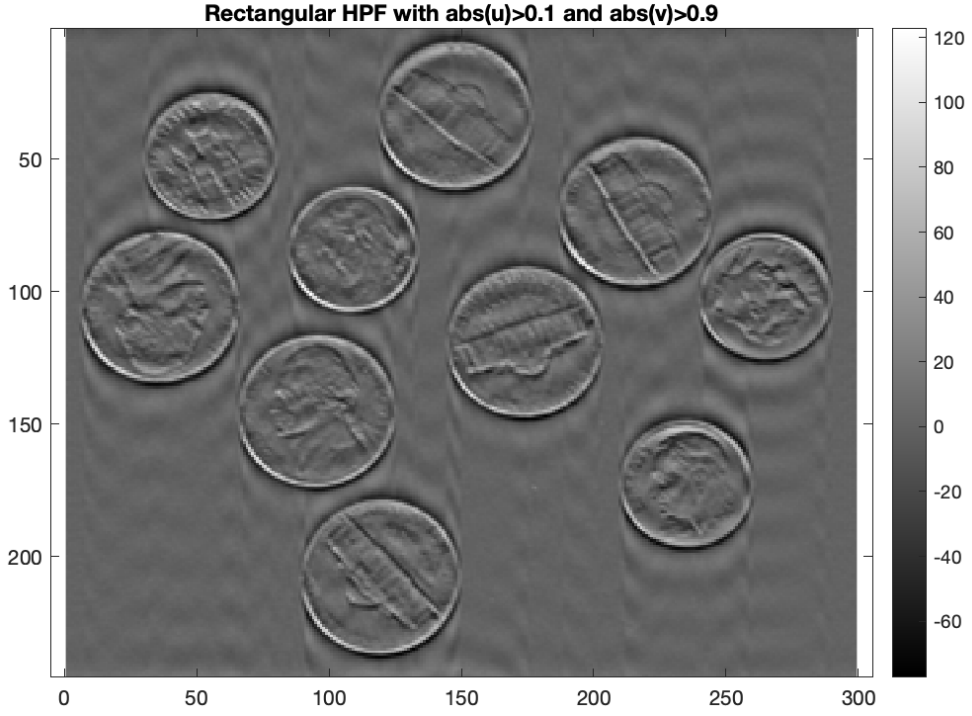
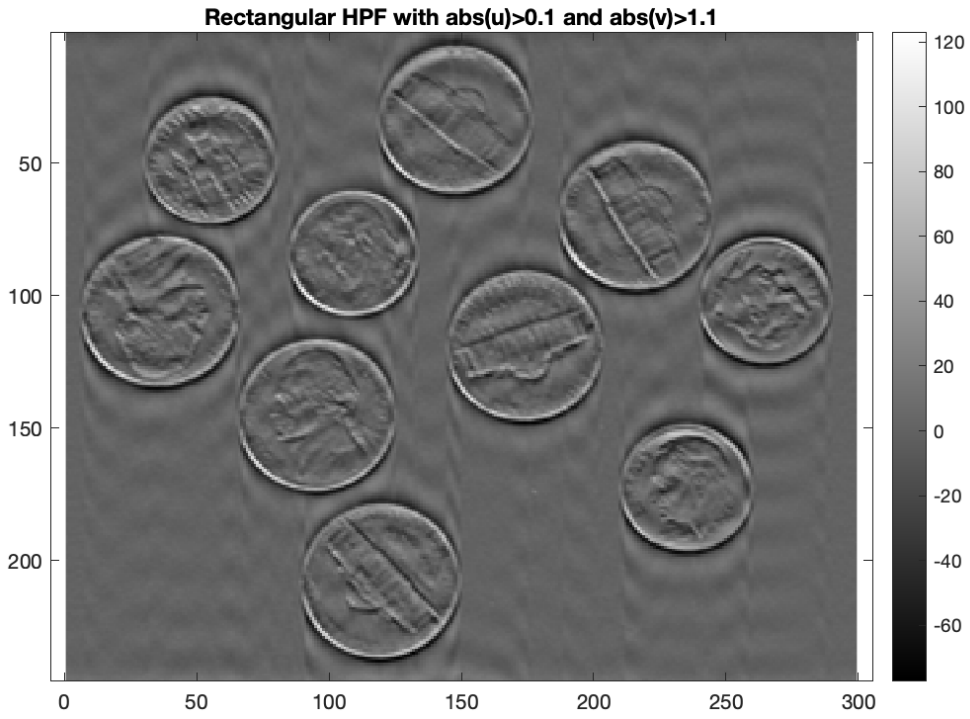
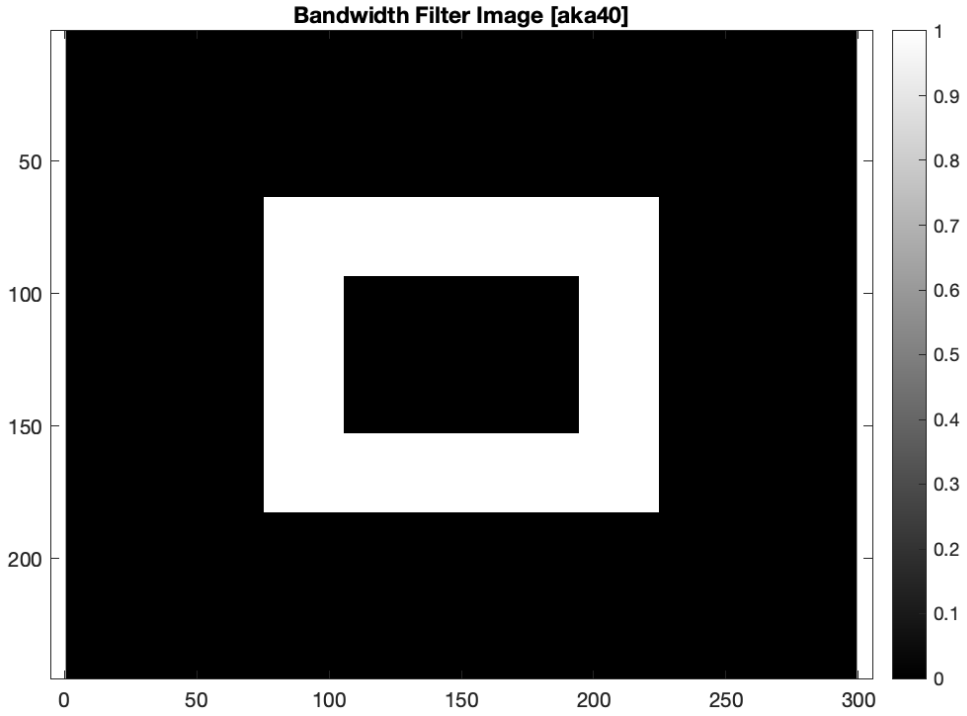
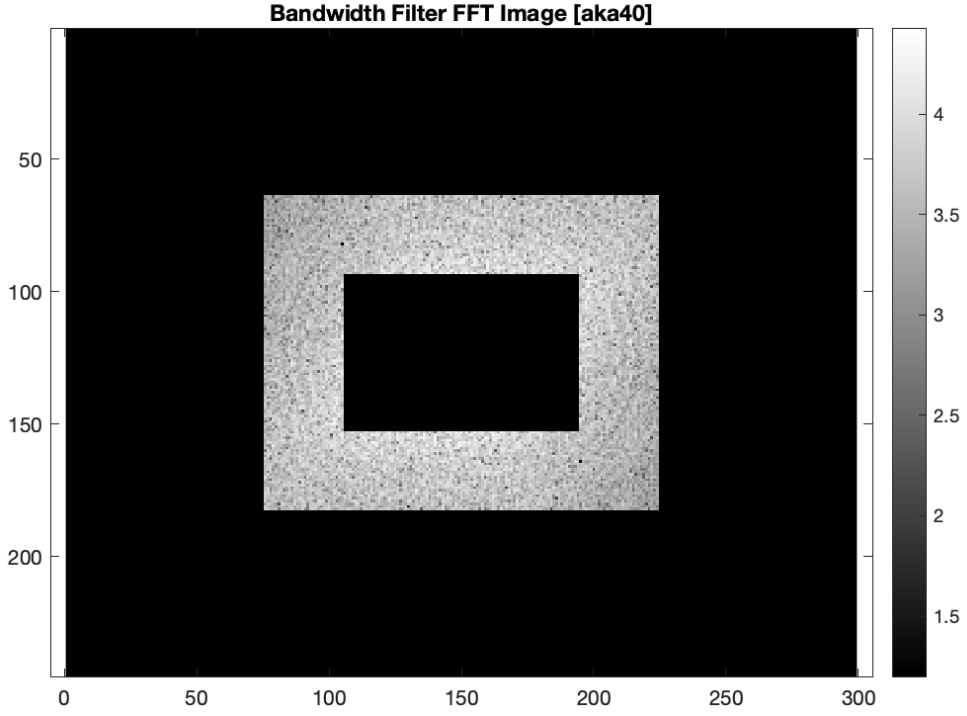
100
150
200
0
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60

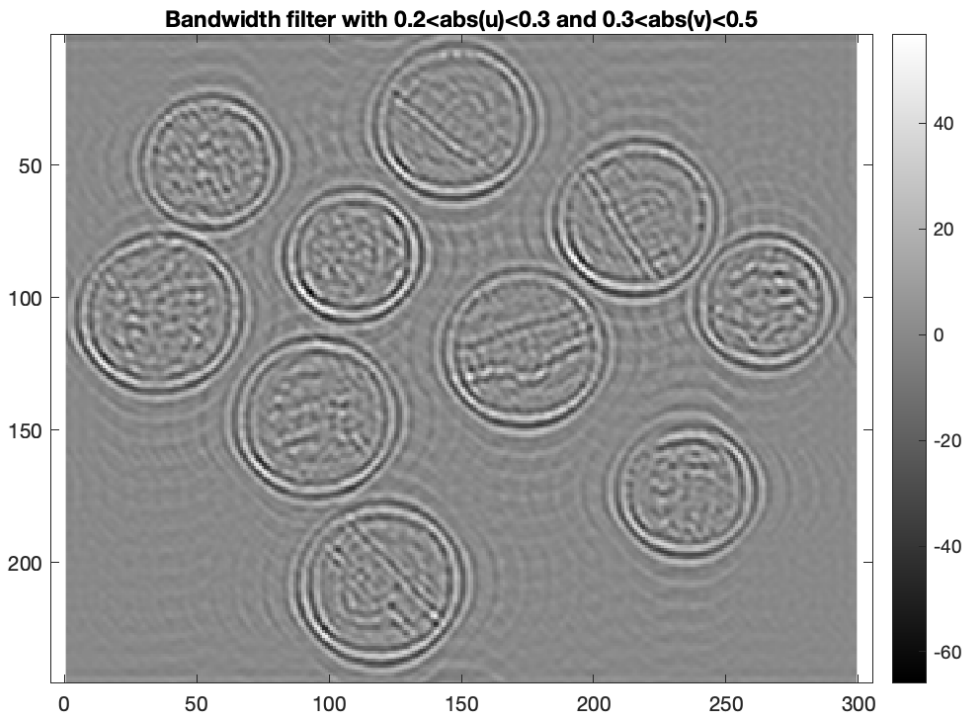

Rectangular HPF with abs(u)>0.1 and abs(v)>0.9
50
100
150
200
0
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60


Rectangular HPF with abs(u)>0.1 and abs(v)>1.1
50
100
150
200
0
50
100
150
200
250
300
120
100
80
60
40
20
0
-20
-40
-60

10.8 Exercise 10






Bandwidth filter with 0.2<abs(u)<0.3 and 0.3<abs(v)<0.5
50
100
150
200
0
50
100
150
200
250
300
40
20
0
-20
-40
-60

11 Codes

11.1 Exercises 1 and 2

```
function [A,B,X]  = analysis(arr)
M=length(arr);

A= zeros(1,M);
B= zeros(1,M);
X= zeros(1,M);
for k = 1:M
    for m= 1:M
    A(k) = A(k) + arr(m)* cos( 2 * pi/5 *(k-1)* (m-1));
    B(k) = B(k) + arr(m)* sin( 2 * pi/5 *(k-1)* (m-1));
    X(k) = X(k) + arr(m)* exp( -i *2 * pi/5*(k-1)* (m-1));
    end
end
end
```

```
function x = trig_synth(A,B)
M = length(A);
x = zeros(1,M);

for m = 1:M
    for k= 1:M
    x(m) = x(m)+ A(k) * cos( 2 * pi/M *(k-1)* (m-1)) + ...
                 B(k) * sin( 2 * pi/M *(k-1)* (m-1));
    end
end
x= x/M;
end
```

```
function x = exp_synth(X)
M = length(X);
x = zeros(1,M);

for m = 1:M
    for k= 1:M
    x(m) = x(m) + X(k) * exp(i* 2 * pi/M *(k-1)* (m-1));
    end
end
x= x/M;
end
```

11.2 Exercise 3

```
clear
x = imread('coins.png');
x = x(2:end, 2:end);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = sqrt(u.^2+v.^2)<0.5;
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.5 [aka40]")
print -dpng IP2_EX3_Plot1.png

filter = sqrt(u.^2+v.^2)<0.4;
figure(6); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(7); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(8); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.4 [aka40]")
print -dpng IP2_EX3_Plot2.png

filter = sqrt(u.^2+v.^2)<0.3;
figure(9); clf
imagesc(filter); axis equal; colormap gray; colorbar
```

```
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(10); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(11); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.3 [aka40]")
print -dpng IP2_EX3_Plot3.png


filter = sqrt(u.^2+v.^2)<0.2;
figure(12); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(13); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(14); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.2 [aka40]")
print -dpng IP2_EX3_Plot4.png


filter = sqrt(u.^2+v.^2)<0.1;
figure(15); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(16); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(17); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.1 [aka40]")
print -dpng IP2_EX3_Plot5.png
```

11.3 Exercise 4

```
clear
x = zeros(399,399);
x(:,:)= randi(255,399);

figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = sqrt(u.^2+v.^2)<0.5;
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.5 [aka40]")
print -dpng IP2_EX4_Plot1.png

filter = sqrt(u.^2+v.^2)<0.4;
figure(6); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(7); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(8); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.4 [aka40]")
print -dpng IP2_EX4_Plot2.png

filter = sqrt(u.^2+v.^2)<0.3;
figure(9); clf
```

```
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(10); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(11); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.3 [aka40]")
print -dpng IP2_EX4_Plot3.png


filter = sqrt(u.^2+v.^2)<0.2;
figure(12); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(13); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(14); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.2 [aka40]")
print -dpng IP2_EX4_Plot4.png


filter = sqrt(u.^2+v.^2)<0.1;
figure(15); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(16); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(17); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.1 [aka40]")
print -dpng IP2_EX4_Plot5.png
```

11.4 Exercise 5

```
clear
x = zeros(399,399);
x(:,:)= randi(255,399);

figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = sqrt(u.^2+v.^2)<0.006;
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
title("LPF of Radius 0.006 [aka40]")
print -dpng IP2_EX5_Plot1.png

filter = sqrt(u.^2+v.^2)<0.06;

Xsfiltered = Xs.*filter;
Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(6); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("LPF of Radius 0.006 without Scaling [aka40]")
print -dpng IP2_EX5_Plot6.png

figure(7); clf
surfc(xfiltered); colormap gray; shading interp; colorbar
title("Surface of LPF of Radius 0.006 without Scaling [aka40]")
print -dpng IP2_EX5_Plot7.png
```

11.5 Exercise 6

```
clear
x = imread('coins.png');
x = x(2:end, 2:end);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = (abs(u)<0.5) & (abs(v)<0.5);
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
print -dpng trash.png

title("Rectangular LPF with |u|<0.5 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot1.png


filter = (abs(u)<0.5) & (abs(v)<0.4);
figure(6); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(7); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(8); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
print -dpng trash.png

```

```
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
```

```
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.5 and |v|<0.1 [aka40]")

print -dpng IP2_EX6_Plot5.png

filter = (abs(u)<0.4) & (abs(v)<0.5);
figure(18); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(19); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(20); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar
print -dpng trash.png

title("Rectangular LPF with |u|<0.4 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot6.png


filter = (abs(u)<0.3) & (abs(v)<0.5);
figure(21); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(22); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(23); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.3 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot7.png

filter = (abs(u)<0.2) & (abs(v)<0.5);
figure(24); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(25); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
```

```
xfiltered = ifft2(Xfiltered);
figure(26); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.2 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot8.png

filter = (abs(u)<0.1) & (abs(v)<0.5);
figure(27); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(28); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(29); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot9.png

filter = (abs(u)<0.01) & (abs(v)<0.5);
figure(30); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(31); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(32); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.01 and |v|<0.5 [aka40]")

print -dpng IP2_EX6_Plot10.png
```

11.6 Exercise 7

```
clear
x = zeros(399,399);
x(:,:)= randi(255,399);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = (abs(u)<0.5) & (abs(v)<0.5);
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.5 and |v|<0.5 [aka40]")

print -dpng IP2_EX7_Plot1.png


filter = (abs(u)<0.1) & (abs(v)<0.5);
figure(6); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(7); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(8); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")

```

```
print -dpng IP2_EX7_Plot2.png

filter = (abs(u)<0.1) & (abs(v)<0.5);
figure(9); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(10); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(11); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.1 and |v|<0.5 [aka40]")

print -dpng IP2_EX7_Plot3.png

filter = (abs(u)<0.1) & (abs(v)<0.1);
figure(12); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(13); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(14); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.1 and |v|<0.1 [aka40]")

print -dpng IP2_EX7_Plot4.png
```

11.7 Exercise 8

```
clear
x = zeros(399,399);
x(:,:)= randi(255,399);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = (abs(u)<0.006) & (abs(v)<0.006);
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
filter = (abs(u)<0.006) & (abs(v)<0.006);
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered, [0, 255]); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.006 and |v|<0.006 [aka40]")

print -dpng IP2_EX8_Plot1.png

figure(6); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar

title("Rectangular LPF with |u|<0.006 and |v|<0.006 no Scaling [aka40]")

```

```
56 print -dpng IP2_EX8_Plot6.png
57
58
59 figure(7); clf
60 surfc(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

```
x = imread('coins.png');
x = x(2:end, 2:end);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png

[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
filter = (abs(u)>0.1) | (abs(v)>0.1);
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.1");
print -dpng IP2_EX9_Plot1.png


filter = (abs(u)>0.3) | (abs(v)>0.1);
figure(6); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(7); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(8); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.3 and abs(v)>0.1");
print -dpng IP2_EX9_Plot2.png

filter = (abs(u)>0.5) | (abs(v)>0.1);
figure(9); clf
imagesc(filter); axis equal; colormap gray; colorbar
```

```
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(10); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(11); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.5 and abs(v)>0.1");
print -dpng IP2_EX9_Plot3.png

filter = (abs(u)>0.7) | (abs(v)>0.1);
figure(12); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(13); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(14); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.7 and abs(v)>0.1");
print -dpng IP2_EX9_Plot4.png

filter = (abs(u)>0.9) | (abs(v)>0.1);
figure(15); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(16); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(17); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.9 and abs(v)>0.1");
print -dpng IP2_EX9_Plot5.png

filter = (abs(u)>1.1) | (abs(v)>0.1);
figure(18); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(19); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png
```

```
113
114 Xfiltered = ifftshift(Xsfiltered);
115 xfiltered = ifft2(Xfiltered);
116 figure(20); clf
117 imagesc(xfiltered); axis equal; colormap gray; colorbar
118 title("Rectangular HPF with abs(u)>1.1 and abs(v)>0.1");
119 print -dpng IP2_EX9_Plot6.png
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");
```

```
print -dpng IP2_EX9_Plot9.png

filter = (abs(u)>0.1) | (abs(v)>0.9);
figure(30); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(31); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(32); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.9");
print -dpng IP2_EX9_Plot10.png

filter = (abs(u)>0.1) | (abs(v)>0.9);
figure(33); clf
imagesc(filter); axis equal; colormap gray; colorbar
print -dpng trash.png

Xsfiltered = Xs.*filter;
figure(34); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
print -dpng trash.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(35); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Rectangular HPF with abs(u)>0.1 and abs(v)>0.9");
print -dpng IP2_EX9_Plot11.png
```

11.9 Exercise 10

```
clear
x = imread('coins.png');
x = x(2:end, 2:end);
figure(1); clf
image(x); axis equal; colormap gray; colorbar
print -dpng trash.png

X = fft2(x);
Xs = fftshift(X);
figure(2); clf
imagesc(log10(abs(Xs))); axis equal; colormap gray; colorbar
print -dpng trash.png


[rows, cols] = size(x);
max_size = max(rows, cols);
rnorm = rows/max_size; cnorm = cols/max_size;
[v, u] = meshgrid(linspace(-cnorm, cnorm, cols),...
    linspace(-rnorm, rnorm, rows)) ;
HPF = (abs(u)>0.2) | (abs(v)>0.3);
LPF = (abs(u)<0.4) & (abs(v)<0.5);
filter = HPF.*LPF;
figure(3); clf
imagesc(filter); axis equal; colormap gray; colorbar
title("Bandwidth Filter Image [aka40]");
print -dpng IP2_EX10_Plot1.png

Xsfiltered = Xs.*filter;
figure(4); clf
imagesc(log10(abs(Xsfiltered))); axis equal; colormap gray; colorbar
title("Bandwidth Filter FFT Image [aka40]");
print -dpng IP2_EX10_Plot2.png

Xfiltered = ifftshift(Xsfiltered);
xfiltered = ifft2(Xfiltered);
figure(5); clf
imagesc(xfiltered); axis equal; colormap gray; colorbar
title("Bandwidth filter with 0.2<abs(u)<0.3 and 0.3<abs(v)<0.5");
print -dpng IP2_EX10_Plot3.png
```