Work Sheet TWO

The aim of this computer based exercise is to reinforce the material that you have covered during the lectures. Your have 2 hours to complete this worksheet, after which you will be required to complete a 30 minute test.

You may refer to your lecture notes, other reference sources, such as text book and websites and confer which your colleges to complete the exercises, however the test is a closed note assessment and must be done individually.

The image required for this worksheet can be found at:
http://newton.ex.ac.uk/teaching/resources/jjm/pam3012/Labs/index.html

Exercise 1: Averaging and Gradients

1(a)   Moving Average
- Open image MRhead1.jpg
- Draw a line from point O to point P.
- Plot the intensity profile along this line.
- Copy and export the data into columns A and B of an Excel spreadsheet, starting at cell A1.
- Plot the profile using a scatter graph with data points connected with smooth lines without markers – this should appear as it did in ImageJ.

Smoothing average with a filter width = 3
- In cell C2 type "=(B1+B2+B3)/3"
- Copy this cell into the entire column (Highlight cell and drag outside to cover entire column)
- Plot columns B and C vs column A (again use a scatter graph with data points connected with smooth lines without markers)
- What is the difference between C and B?
- Save this spreadsheet in you personal work folder

Smoothing average with a filter width = 5
- In cell D3 type "=(B1+B2+B3+B4+B5)/5"
- Copy this cell into the entire column (Highlight cell and drag outside to cover entire column)
- Plot column D vs column A (again use a scatter graph with data points connected with smooth lines without markers)
- What is the difference between D and C?
- Save this spreadsheet in you personal work folder

The Effect of Filter Width
- Repeat the previous procedure for various filter widths (i.e. the number of data points used to generate the average).
- What is the relationship between the filter width and the width of the feature that are removed form the profile.

1(b)   Gradient Enhancement

- Open the spreadsheet containing the moving average filter with a of 5 data points.
- Column D should contain the filtered image profile.

1st Derivative (Gradient)

- In cell E4 type '=(-D3+2*D4-D5)'
- Copy this cell into the entire column (Highlight cell and drag outside to cover entire column)
- Plot columns D and E vs column A (again use a scatter graph with data points connected with smooth lines without markers)
- What is the relationship between D and E?
- What is the purpose of smoothing the data before sharpening?

2nd Derivative

- Filter the 1st derivative (gradient) using a moving average filter with sufficient width to remove the unwanted features. Beware, if the filter is too wide it will remove the features that you want to keep!
- Apply the gradient equation to the smoothed version of the 1st derivative.
- What is the relationship between the 1st and 2nd derivative?
- What is the purpose of smoothing the data before sharpening?

Exercise 2: Smoothing Spatial Filtering

2(a)   Smoothing Spatial Filters:

Mean or Box Filter
- Open image 2-1.jpg (shown below)
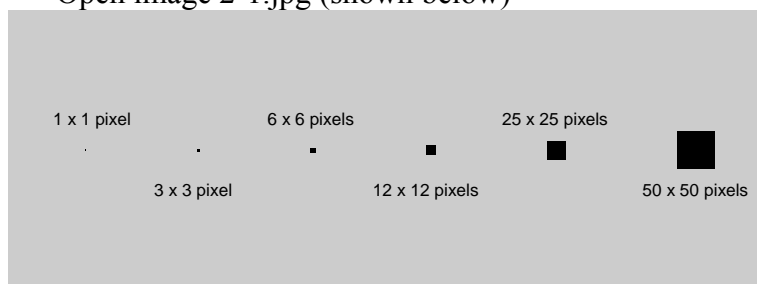
- Process, Filter, Mean
- Set the radius
- Select 'Separable Square Mask'
- Experiment with the radius size.
- Repeat with various sizes of median filter. (Process, Filter, Median)
- Note how the squares disappear rather than becoming blurred.

Smoothing Images
- Open image 'Wrinkles.jpg'
- The effectiveness of various different filter types and sizes of removing the effect of wrinkles.

2(b)   Noise Reduction using Averaging Filters

Salt and Pepper Noise
- Open image 2-2.jpg
- This image consist of a grey background corrupted with *salt and pepper* noise.
- Plot the PDF of this image.
- What would the PDF look like without noise?
- Filter the image with a mean filter.
- After filtering re-plot the PDF.
- Filter the image with a median filter.
- After filtering re-plot the PDF.

- Open image Albert-Salt&Pepper.jpg
- This image has been corrupted with *salt and pepper* noise
- Filter the image with a median filter.
- How does the filter radius affect the outcome?

Gaussian Noise
- Open image 2-3.jpg
- This image consists of a grey background corrupted with *Gaussian* noise.
- Plot the PDF of this image.
- What would the PDF look like without noise?
- Filter the image using a median filter.
- Re-plot the PDF.
- Filter the image using a mean filter.
- Re-plot the PDF.

- Open image Albert-Gaussian.jpg
- This image has been corrupted with *Gaussian* noise
- Filter the image with a mean filter.
- How does the filter radius affect the outcome?

Exercise 3: Sharpening Spatial Filters

3(a)   Sharpening Spatial Filters:
- Open image London.jpg
- Process the image using the built-in 'Sharpen' function (Process, Sharpen)

3(b)   Custom Sharpening Filter
- Open image London01.jpg
- Process the image using a user defined filter (Process, Filters, Convolve)
- The convolver window allows you to enter ANY filtering mask.
- Start with filters (a) and (b)

(Filter a)

-1	-1	-1
-1	α	-1
-1	-1	-1

(Filter b)

-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	β	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1

- Starting with filter (a), investigate how different values of the central weighting coefficient, α, effect the outcome.
- Uncheck 'Normalize Kernel'
- Repeat the process with filter (b), again investigate how different values of the central weighting coefficient, β, effect the outcome.

4(a)   Combined Enhancement:
- Open image MRhead1.jpg
- Filter the image using filter (b) with $\beta = 24$
- Note the sharpening filter has also high-lighted unwanted features – noise
- To remove the noise, process the image using a 'mean' filter with a 3 pixel radius.
- Process the resulting using a gamma enhancement of 1.7
- Save this image
- Using the 'image calculator' function, add this image to the original image.

- Repeat this process for image Hand.jpg
- You may need to experiment with the gamma value to achieve the optimal results