COMS21202 – Symbols, Patterns and Signals

Problem Sheet B: Representations and Features

1 – Calculate the result of the convolution $A*B$ in each of the examples below by hand.

(i) $A = \begin{pmatrix} 1 & 2 & 1 \end{pmatrix}$ $\quad B = \begin{pmatrix} 2 & 2 & 3 & 3 & 2 \end{pmatrix}$

(ii) $A = \begin{pmatrix} 1 & 1 & 3 & 1 & 1 \end{pmatrix}$ $\quad B = \begin{pmatrix} 3 & 3 & -2 & -1 & 0 & 1 & 2 & 3 & 3 \end{pmatrix}$

(iii) $A = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$ $\quad B = \begin{pmatrix} 0 & 5 & 5 & 5 & 0 \\ 0 & 5 & 10 & 5 & 0 \\ 0 & 10 & 10 & 10 & 0 \\ 0 & 5 & 10 & 5 & 0 \\ 0 & 5 & 5 & 5 & 0 \end{pmatrix}$

Now verify your result using the *conv* family of functions in Matlab. Use *help conv* to determine what convention Matlab uses when convolving at the border points.

2 – How would low pass filtering be achieved using the Fourier domain? In your answer describe what is meant by Cut-off Frequency.

3 – Consider you are given the Fourier Transform space of an image. Using simple sketches to illustrate your answer, how would you select relevant regions to extract spectral features from

(a) only low frequency regions,
(b) only the very high frequency regions corresponding to prominent variations in intensity in the image that are at around 45_ to the horizontal,
(c) all approximately mid-range frequencies.

4 – Convolution in the spatial domain is equivalent to multiplication in the frequency domain, i.e. $f*g = FG$ (see Convolution lecture).

(a) Write a Matlab program that demonstrates $f*g = FG$ using any NxN image f and a $5x5$ averaging filter g consisting of all *1*s. (Hint: you will need to pad g with zeros to make it the same size as the image before using fft2 in Matlab).
(b) Use Matlab's clock command to time how convolution in the spatial domain compares with multiplication in the Fourier domain.

5 – Imagine you have received a huge shipment of three variety of fruits consisting of *Oranges*, *Satsumas*, and *Red Pears*. The fruit is unfortunately mixed up, but you have access to a vision system you can program to distinguish and separate the fruit as they pass in front of a camera on a converyor belt one at a time. The camera is positioned to give a top-view of the fruit.

(a) State no fewer than three, and no more than five, features you would use in your design to distinguish between the different types. Very briefly explain why your features will pick the correct type each time considering that some measurements maybe somewhat affected by noisy data from the image acquisition process.
(b) Consider you had actually been asked to consider using up to 20 features for this task. Discuss what would you do to find out which features are significant (or which ones are redundant)?

6 – Use the "dopca" program available on the unit www page to upgrade it to a 3D case called "dopca3D" which does exactly the same tasks but on a 3D data set. You can make the data up if you like or use these values to add to the current 2D data in "dopca":

```
[7.0 7.4 6.2 6.4 6.6 7.0 6.9 7.1 6.5 7.1];
```

7 – Use Rotate an object, Fourier space rotates too. Translate an object, Fourier space translates too

(a) Both statements are **True**.
(b) First statement is **True** and second one is **False**.
(c) First statement is **False** and the second one is **True**.
(d) Both statements are **False**.

8 – A 3x3 spatial filter with all elements set to **−1,** except the central element set to **16,** has a...

(a) normalisation factor of *1/8*
(b) normalisation factor of *1/16*
(c) normalisation factor of *1/0*
(d) normalisation factor of *1/12*

9 – The eigenvalues of a dataset are: **[17, 11, 8, 2, 0.65, 0.35]**. What *variance* in the dataset do the first 3 eigenvalues represent?

(a) 93.2%
(b) 91.3%
(c) 96.3%
(d) 92.3%