

COMS20011 – Data-Driven Computer Science

Problem Sheet MM04

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

$$\begin{aligned} \text{(i)} \quad A &= \begin{pmatrix} 1 & 2 & 1 \end{pmatrix} & B &= \begin{pmatrix} 2 & 2 & 3 & 3 & 2 \end{pmatrix} \\ \text{(ii)} \quad A &= \begin{pmatrix} 1 & 1 & 3 & 1 & 1 \end{pmatrix} & B &= \begin{pmatrix} 3 & 3 & -2 & -1 & 0 & 1 & 2 & 3 & 3 \end{pmatrix} \\ \text{(iii)} \quad A &= \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} & B &= \begin{pmatrix} 0 & 5 & 5 & 5 & 0 \\ 0 & 5 & 10 & 5 & 0 \\ 0 & 10 & 10 & 10 & 0 \\ 0 & 5 & 10 & 5 & 0 \\ 0 & 5 & 5 & 5 & 0 \end{pmatrix} \end{aligned}$$

Now verify your result using Matlab (using *conv* and use *help conv* to determine what convention Matlab uses when convolving at the border points) or using Python.

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 degrees to the horizontal,
- (c) all approximately mid-range frequencies.

4 – 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 conveyor 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)?

5 – 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**.

6 – 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 $1/24$
- (d) normalisation factor of $1/12$

7 – The eigenvalues of a 6D 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%