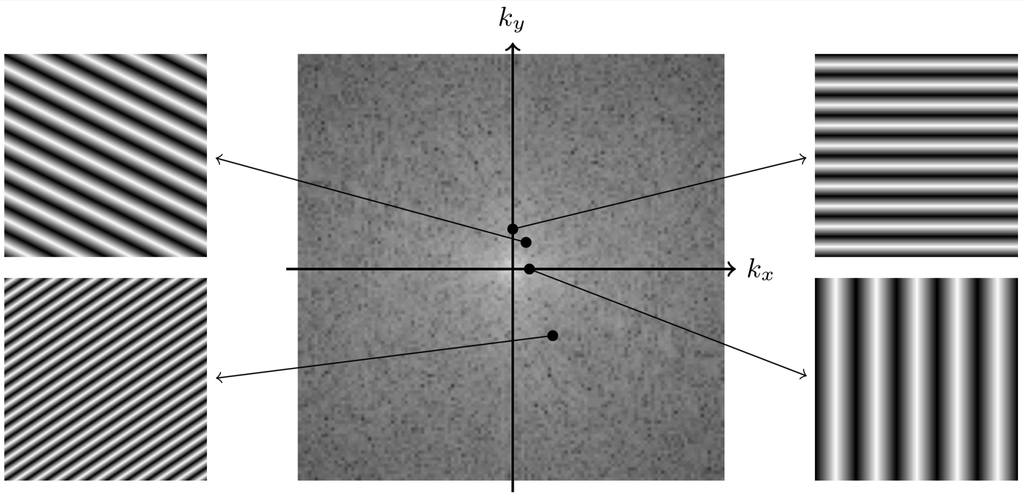
Department of Computer Science
University of Bristol

COMS30030 - Image Processing and Computer Vision



Problem Feedback - Week 02

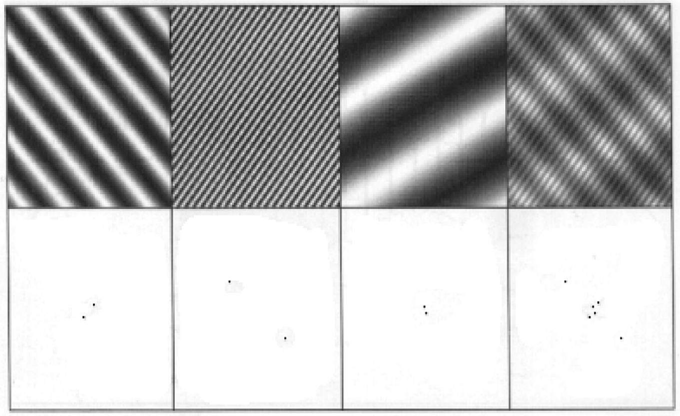
Key Points, Feedback and Comments

Key Points

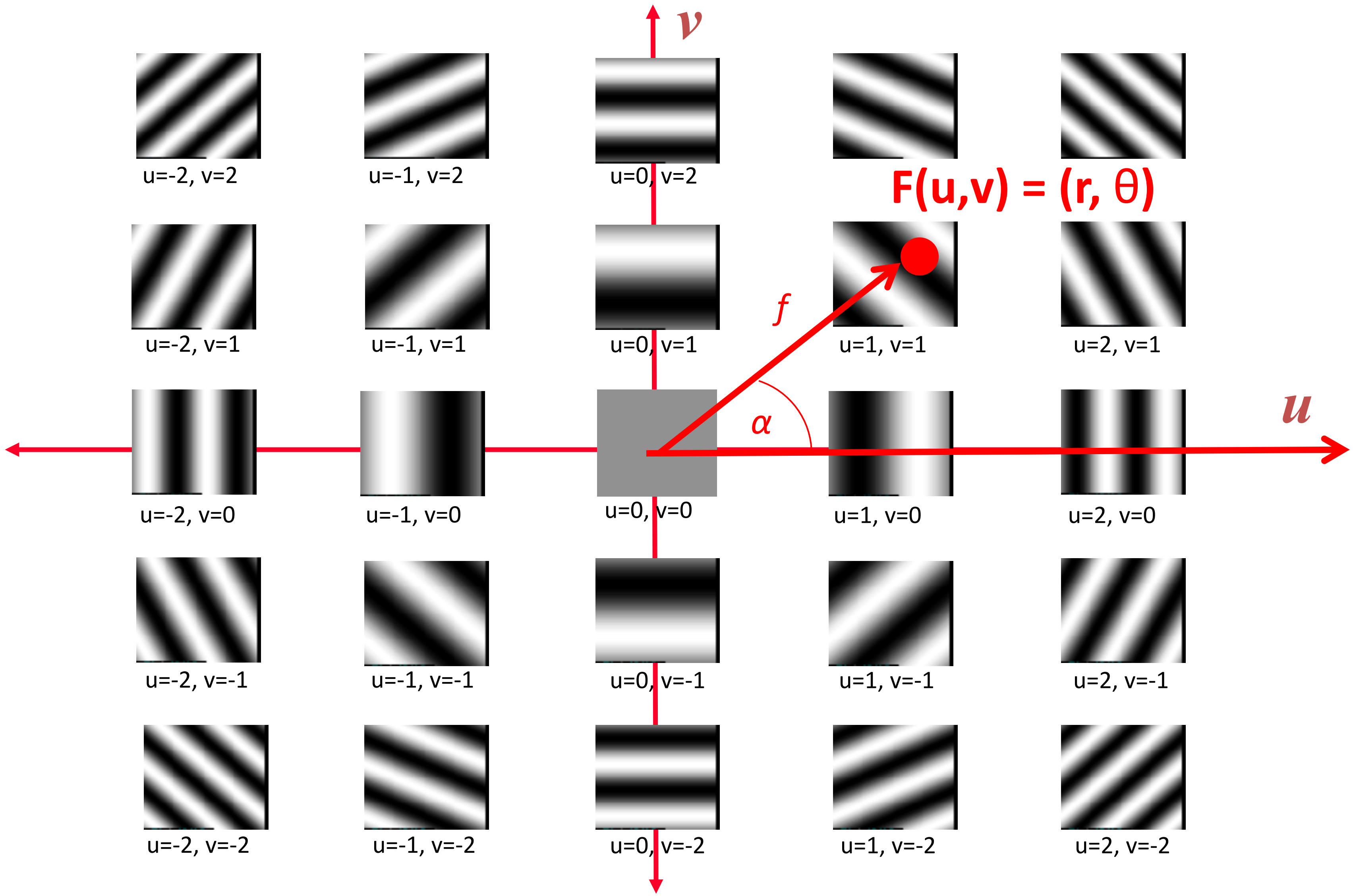
a) Ideal Sinusoid Waves, their Spatial Frequency and their Orientation

Since sinusoids are the **basis functions** of the Fourier Space; they form the coefficient set of this space and are, thus, represented in the spectrum (e.g. the power spectrum showing the magnitude component of the frequency spectrum) at **particular locations**. Their distance to the origin determines the frequency of the sinusoid wave, the angle alpha (see next slide) defines their orientation in the image, i.e. the direction of the wavefront.

Also note that any single sinusoid wave can be reconstructed from two different coefficients – they differ in the power spectrum by rotation of180 degrees. Thus, a sine pattern in an image shows TWO distinct locations in the power spectrum.



‘Fabric’ of the 2D Fourier Space

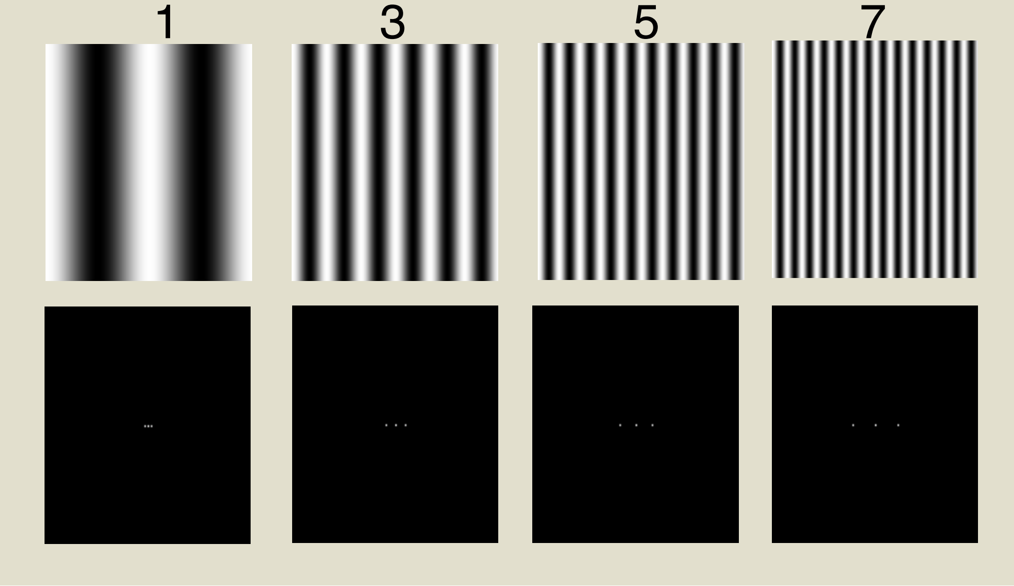


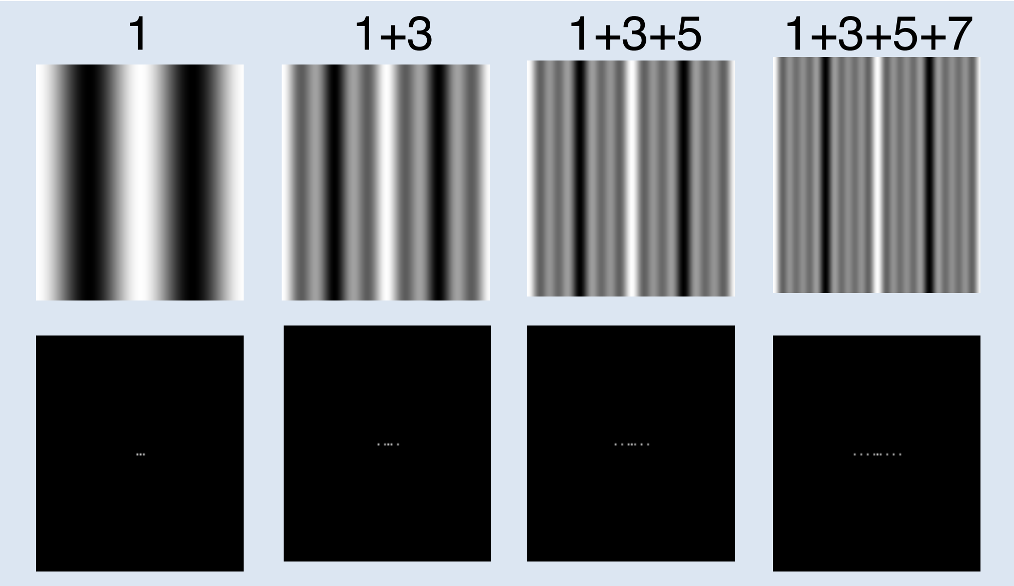
Perpendicular relationship

b) line structures, edges and their orientation

Ideal edge and line structures have a concentration of energy along a line passing through the origin in the frequency domain and in a **direction perpendicular to their orientation** - they are 'constructed' by adding together all 2D sinusoidal waves that 'travel' perpendicular to the edge or line.

Brightness Image Fourier transform





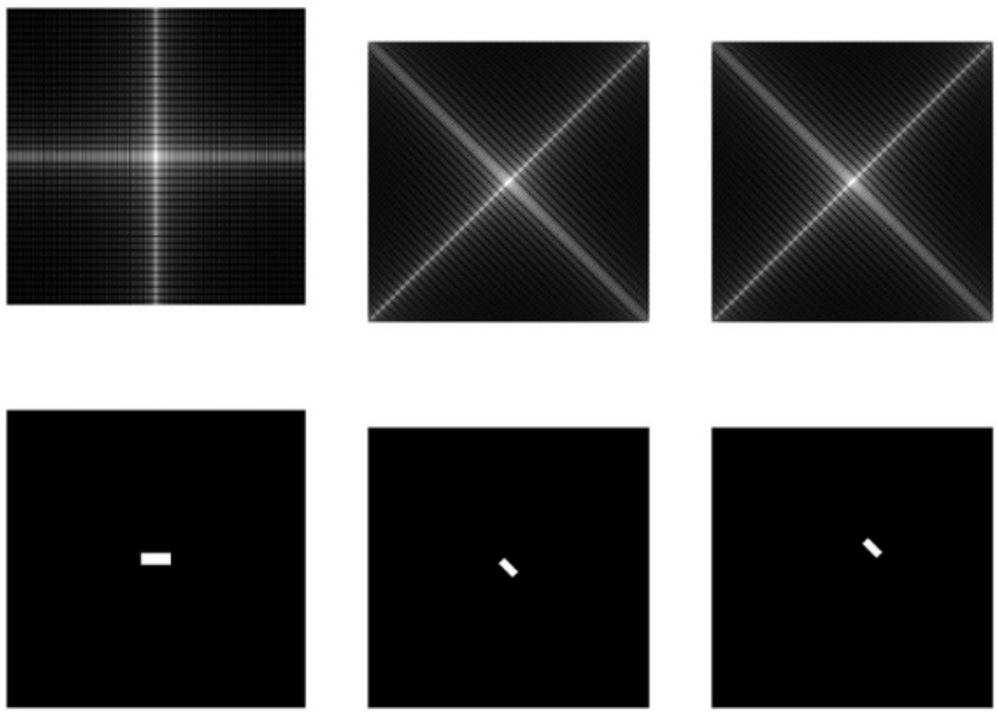
Rotation/Translation Illustrated

c) shift of elements

Spatial shifts result in a linear phase change in the frequency domain, but no change in the magnitude spectrum. Hence, the magnitude spectrum of a line or dot, for example, looks the same wherever it is in the image.

d) rotation of elements

Rotation of an image in the spatial domain results in a corresponding rotation in the Fourier domain.

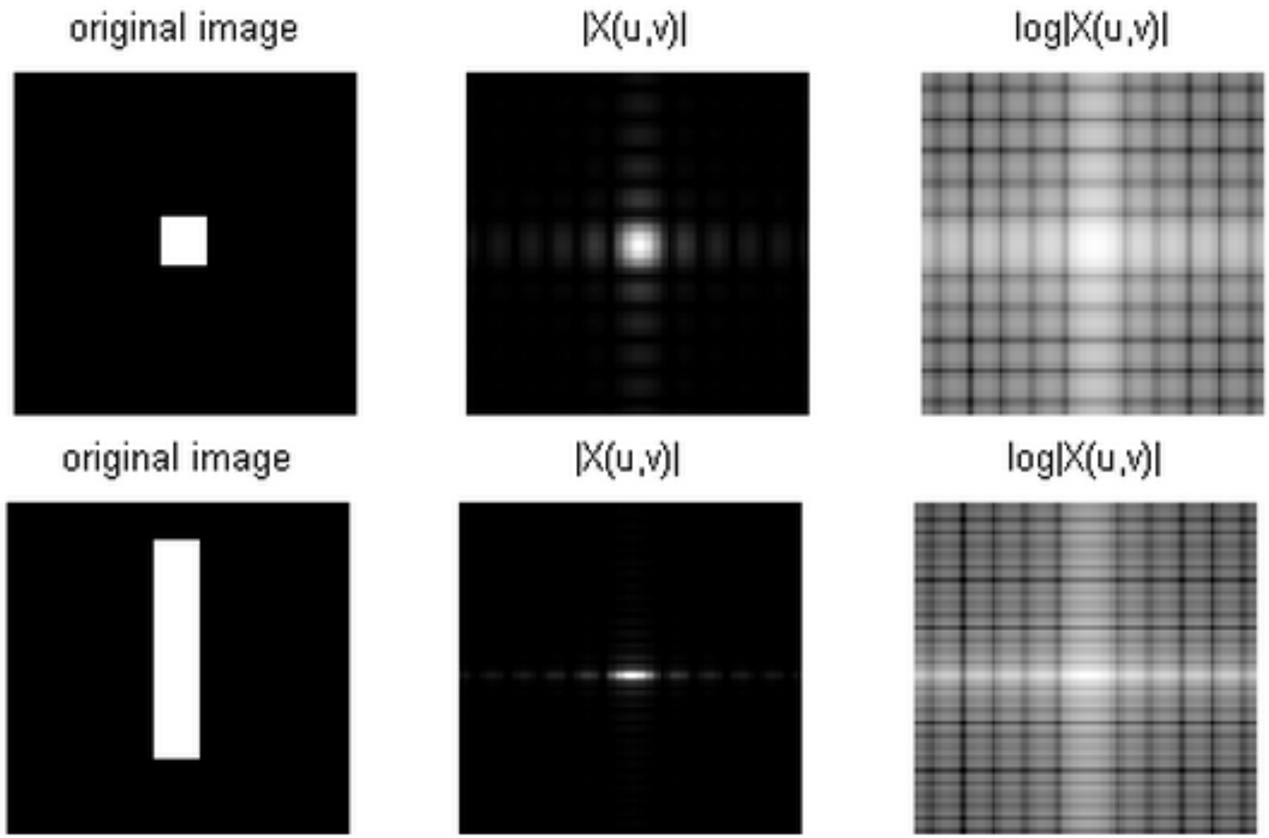


Rotation Rotation & translation

Scaling Illustrated

e) scaling of elements

There is an **inverse scaling relationship**. Expansion in the spatial domain gives rise to contraction in the frequency domain and vice versa. Larger structures gives rise to more energy about the origin due to the spectrum being contracted.



Contrast, Randomising, Filtering

f) contrast and structure AND

i) power randomisation

In general the **magnitude spectrum determines the contrast** and dynamic range of colours in an image whilst the phase determines the structure. Phase is responsible for sinusoids to 'line up' correctly to make a desired image. Thus, if we randomise the magnitude values, we get an image which retains the structure of the original (it still looks like the original), but loses the colour contrast. In contrast, if we randomise the phase then we lose the structure altogether and the resulting image bears little resemblance to the original.

g/h) effects of high pass/low pass

As can be clearly seen in images 5 to 8, **cutting out high frequencies blurs the image** and **cutting out low frequencies increments the image sharpness**. Cutting out frequencies below and above some window, i.e. only leaving a ring of information in the power spectrum as in image 7, enhances frequencies in this narrow band and suppresses all others (intuitively similar to tuning into a certain frequency on a radio). This is a band-pass filter. Note that filtering by cutting frequencies can cause unwanted artefacts (e.g. ripples in images 6 to 8).

Contrast, Randomising, Filtering

Again, note that the power spectrum doesn’t provide information about where things are in the image. For example, in the zebra image, we can see from the magnitude spectrum that there are linear structures present (lines and edges) in different orientations, but it does not tell us where they are (that information is of course encoded in the phase image but ’scrambled’ with that for all the other different structures and patterns in the image).

Overall, a frequency representation gives us a different view of the information present in an image, which can be useful for many tasks, such as filtering. We can easily suppress or enhance certain frequencies, as in low, high or band-pass filtering, or isolate particular image structures with characteristics frequency patterns.