Week 2: Digital Image Data

DIGITAL ASSET DEVELOPMENT

Contents

- Basic digital image concepts
- Colour spaces
- Histograms and their uses

Digital Images

- Recall last week that digital photographs are captured via a CCD (or similar)
  - Light intensity at each CCD sensor is sampled and digitised
  - This gives a grid or array of numbers
  - Also known as bitmap or raster images
- Such images can also be made by:
  - Scanning a document
  - Rendering a 3D scene with a virtual camera

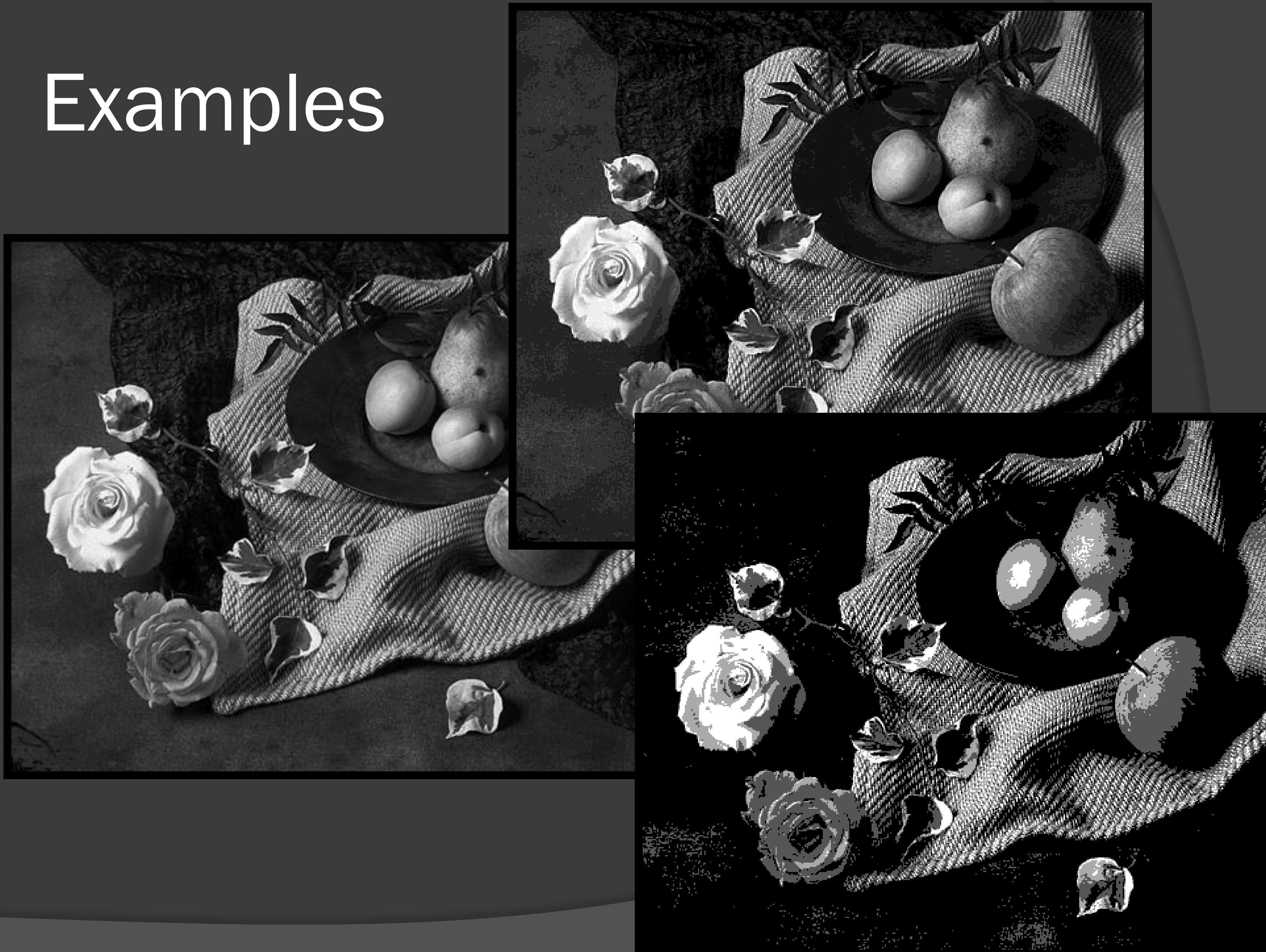
Image Capture

- Each sensor has a finite dynamic range
  - The difference between “black” (no light detected) and “white” (saturation point)
- The dynamic range is divided into a fixed number of segments
  - Traditionally, this number is a power of 2
  - Most common is 256
- The division process depends on factors like the camera’s exposure settings

Image Quality

- The more divisions we use, the better the quality of the resulting image
  - In effect, we are throwing away less information
- In a monochrome (or greyscale) image, 256 divisions can be enough
  - Much fewer, and some flaws will become apparent on close inspection
  - Depends in part on image content

Examples



High Quality Images

- For some specialist applications, we need very high precision
  - More than 256 divisions can allow for
  - Examples: medical or scientific imaging
- In these cases a common solution is to use 65536 divisions
  - Obviously quite an improvement!
- Note that this is not the same as HDR imagery (more on this later)

Bit Depth

- Where do these numbers come from?
- All computer systems like to store data in powers of 2
  - Corresponds to number of bits required to define a number in binary
  - eg. $2^8 = 256$, so 8 bits can define 256 levels
  - Similarly, 16 bits define 65536 values
- We refer to these as bit depths of 8 and 16 respectively

Pixels

- Each member of the array of numbers in a digital image is referred to as a pixel
  - Short for “picture element”
- In a “raw” image, pixels are indivisible units – we cannot zoom in any further
  - To do so leads to “pixelation”
- Every pixel has the following properties:
  - Its location in the array (x and y coordinate)
  - Its value, represented as a digital number

Pixel Values

- The range of potential pixel values is governed by the image's bit depth
- Thus, an 8 bit image has pixel values encoded in the range 0 to 255
  - NB: not 1 to 256 (it's a computer thing!)
- For an uncompressed image, the bit depth also defines the image file size
- As we will see, most file formats reduce the file space needed

Colour Images

- The above assumes that each CCD sensor only measures light intensity
  - Result would be a greyscale image
- Actually, each cell has sensors detecting red, green and blue light
  - We refer to these as colour channels
  - Can treat each channel as a “greyscale” image in its own right (eg. satellite images)
  - Normally combine them into an RGB image

RGB Colour

- RGB is the standard colour space for modern computing
- Most applications typically specify 8 bits for each channel
  - 24 bits in total
  - 256 x 256 x 256 = ~16.7 million colours
  - More than enough for most purposes
- Some specialist areas use higher bit depths (16 bits / channel = 48 bit colour)

Relevance of RGB

- Why are red, green and blue used as primary colours?
  - Partly because they represent different parts of the colour spectrum
  - Partly historical (the technology of image display is based on RGB colour)
- Sometimes other colour models can be more useful
  - Depends on the task set involved

Subtractive Colour

- Red, green and blue add to give white
  - RGB model is also known as additive colour
  - Adds colour to a black screen
- What happens if we <u>start</u> with white?
  - We obtain colours by <u>removing</u> elements of the original white
  - Known as subtractive colour
- Uses cyan, magenta and yellow
  - Complementary to red, green and blue

CMYK Colour

- Subtractive colour is used throughout print industries
- Cyan, magenta and yellow can’t give the full gamut of colours
  - Problems with dark browns and black
  - Have to add black to the mix
- Thus we have <u>four</u> parameters specifying each colour (‘K’ = blacK)
  - Levels usually expressed as percentages

Alpha Channels

- Some tools also use alpha channels to handle transparency in an image
  - Mostly relevant for image editing
- An 8 bit alpha channel offers 256 levels of transparency
- This gives 32 bit RGBA images – 8 bits each for red, green, blue and alpha
  - Especially useful when texturing in a 3D application

Alternative Colour Model

- HSB: hue, saturation and brightness
  - Brightness also termed intensity or value
- Hue defined on “colour wheel” (0-360°)
- Saturation controls purity of colour
  - 0% = grey, 100% = pure hue)
- Brightness varies from black (0%) to the pure colour (100%)
- Very useful in colour design, as it relates colours to their base hue

Limited Colour Spaces

- Do we really need millions of colours?
- Depends on:
  - The nature of the image – some graphics only need a few colours
  - Image “smoothness” – subtle gradations in tone need lots of colours
  - Desired image quality
- Sometimes we can get away with far fewer colours

Indexed Colour

- Can define a representative palette of colours for an image
  - Typically use up to 256 colours
  - This allows 8 bit storage
  - For simple graphics, 16 colours may be OK
- This is known as indexed colour
- In the past, standardised palettes were in common use
  - eg. Web216 (“browser-safe” colours)

Converting Colour Space

- Photoshop allows us to:
  - Identify which colour space an image uses
  - Determine how that colour space is defined
  - Convert an image from one colour space to another
- For example, we may convert RGB data to CMYK for print output
- We can also convert RGB to indexed colour, but quality may be reduced

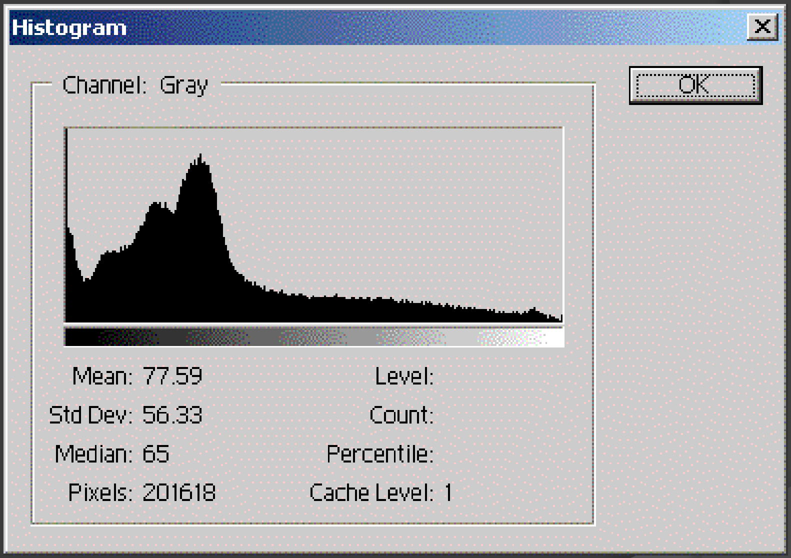
RGB v Indexed Colour

note the “speckle” on the grey background and in some of the shaded areas in the indexed version (right)

The Image Histogram

- Displays visually the intensity profile of a digital image
- For a colour image, we can either:
  - Convert colour values into their greyscale equivalents (called luminosity in Photoshop)
  - Generate histograms for each colour channel
  - Combine red, green and blue data into a single graph
- either way, we can more effectively control image contrast

Example Histogram



Histograms and Contrast