Module: MSC MD (INTMMT) **Seminar 3**

Bitmaps and Colour

Introduction

We will turn our attention to Bitmaps and Colour during this Seminar. As we did in Seminar 2, we will again recommend some applications and encourage you to experiment.

Bitmapped images have none of the complexity of 3D graphics and yet they are the final output from a 3D system. Often the 2D image desired will first be created in 3D and then, after the perspective transformation is applied and it becomes 2D, modified and enhanced. Let us take a look at some ideas associated with Bitmaps.

We start with the resolution or measure of the granularity of the image. It is a common error to assume that an image having 640 by 480 pixels on the screen cover s only that number of phosphor dot triads on the face of the monitor. A screen may state it provides so many dots per inch as its resolution. This is a measure of the manufacturing quality. Depending on the size of the screen we will have a different number of dots per pixel for a given computer resolution. It is also rather short sighted to keep an image at a small resolution since it will look very 'blocky' if enlarged or viewed at a greater resolution than originally stored. This gives rise to large files being kept just in case we need the resolution! One obvious way around this is to compress the image.

Compression schemes are considered to be of two types; Lossy and Lossless. With lossless compression we can always regain the original quality whereas with lossy compression we sacrifice some aspect of quality depending on the application. When dealing with multimedia and the Internet we are very concerned to obtain the best compression ration for a given quality of service (QoS). The compression ratio is given by;

$$\text{Compression Ratio} = \frac{\text{Uncompressed file size}}{\text{Compressed file size}}$$

Most compression schemes rely on taking advantage of redundancy in the data (in our case, the stream of pixels which make up the image). This takes many forms. If we examine one scan line of an image we will notice that many pixels are the same colour so stating for example Red 100 times is wasteful. It is obviously shorter to store the value for red and its length. This is the basic idea behind Run Length Encoding (RLE). A simple compression related to colour is to appreciate that we do not need the full range twenty four bits can provide. If we sample the image for the 256 commonest shades then we can reduce the storage for colour by two thirds by sacrificing fine shading differences. A further approach is useful with video and makes use of the fact that there is redundancy between frames. Not all components of the image move from frame to frame so we need transfer only the changed elements. This is part of the Motion Picture Expert Group (MPEG) standard. We will look at that when we discuss video in seminar 4.

The most common compression standard used in multimedia work today must be the JPEG system from the Joint Photographic Expert Group (JPEG). JPEG is a group of experts (currently over 200 worldwide) who are nominated through their individual national standards organisations. It may surprise you to know that this group started work in the late 1970's on video text! They are currently working on JPEG 2000. Several new features are being implemented particularly several which aid e-Commerce. E.g. Encryption, watermarking, licensing and registration. These will match similar work on MPEG 7 and 21. These new standards although not yet common will change multimedia production and the way we pay for it. JPEG 2000 is available as a Photoshop plug-in and many companies are now making it available, such as; Sanyo on a digital camera, QuickTime and Acrobat Reader version 6. Look for its file extension .JP2.

The current JPEG standard uses the Discrete Cosine Transform (DCT) applied to 8x8 blocks of pixels taken from the image as the basis for compression. See figure 1.

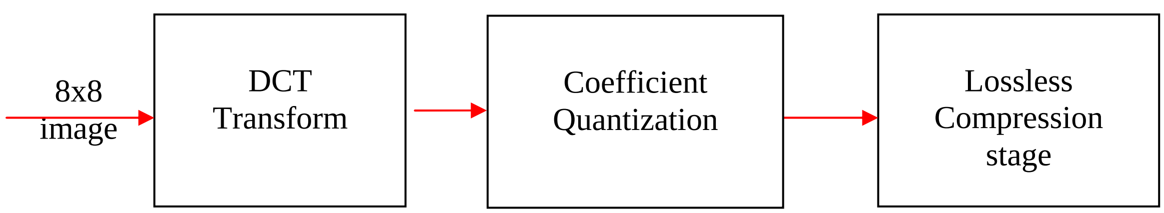

Figure 1. A block diagram of a JPEG encoder.

The DCT produces a set of frequency responses representative of the contents of the series of blocks in the image. For each of these frequencies the values of the coefficients are stored. The coefficients produced by the DCT are quantized and those below a certain value are discarded. In more detail; the difference between the coefficient values and a given level provided by a table is divided by a constant and then stored. The stored values below a threshold are then discarded. These are values which represent high frequency terms and therefore very fine detail and facilities are available to tailor this area. Finally the data stream is Huffman encoded so that no further data is lost. Huffman coding is used because it is a very efficient lossless method. Remember JPEG is lossy due to quantization but this final stage is not.

We will end this lecture with a brief look at some manipulation techniques on Bitmapped images. Many of these techniques have their origins in the Image Processing literature. We cannot cover that field in this module so you are encouraged to look at any standard reference work on the subject or for particular topics use the web. (For a selection, see (11 In the lecture of Seminar 2)).

Since bitmaps are collections of pixels we cannot work on a discrete area directly so we are forced to consider individual pixels. We rapidly realise that is not an option! We need operations that let us work on collections of pixels simultaneously. One class of operations affect the whole of the image, these are masking techniques and are used for smoothing, noise suppression or special effects. They take advantage of a mathematical technique known as convolution and use a convolution mask to scan the image.
Referring to Figure 2 which shows an example based on a 3x3 pixel mask used as the convolution kernel, we see the new image being developed bit by bit. The mask is moved across the image and actions are taken on the image pixel value in the centre of the mask based on the values in the mask. These produce a new modified image in the buffer. So much for the process but how does it work? Why don't we look at one operation in particular. Have a look at figure 3. The figure shows a small image (only nine pixels) which we wish to enlarge. We need to find some new values to go where the zeroes have appeared in the larger image.

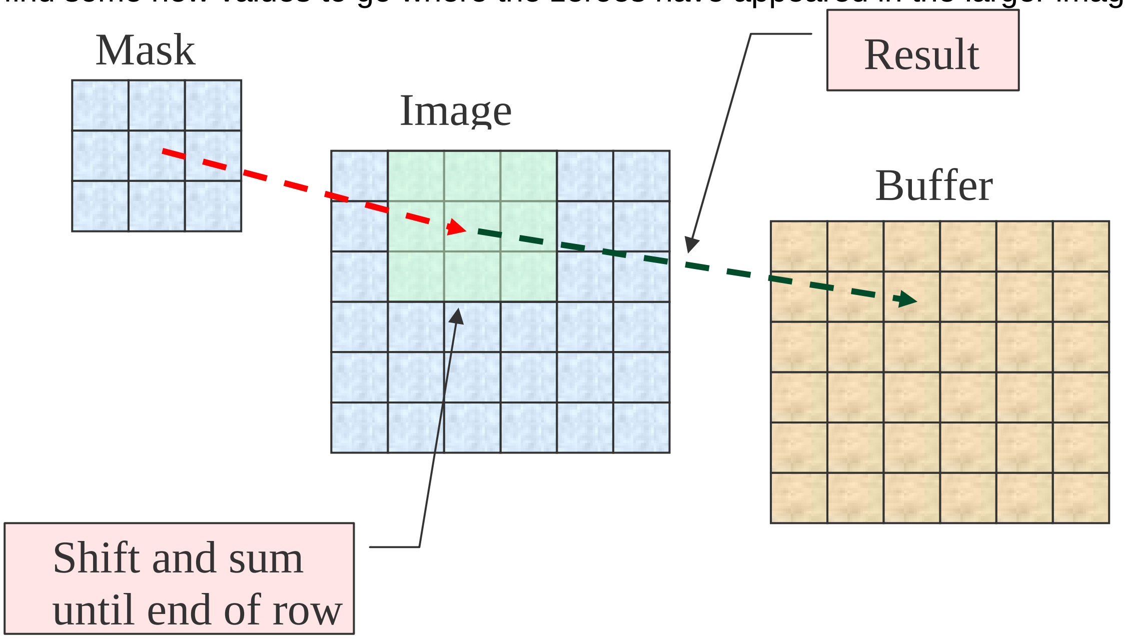

Figure 2. The convolution mask generates a new image as it moves.

$$\begin{bmatrix} 1 & 12 & 21 \\ 3 & 45 & 23 \\ 4 & 22 & 12 \end{bmatrix} \rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 12 & 0 & 21 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 45 & 0 & 23 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 4 & 0 & 22 & 0 & 12 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Figure 3. A small picture of nine pixels was enlarged on the right but it now has zero values in the new pixels. We can fill them by averaging surrounding pixels.

Figure 4 shows a mask which will produce the desired result. Try it for yourself.

$$\begin{bmatrix} 0.25 & 0.5 & 0.25 \\ 0.5 & 1.0 & 0.5 \\ 0.25 & 0.5 & 0.25 \end{bmatrix}$$

Figure 4a. The mask we will use to put average values in place of the zeroes in the enlarged image.

0.25(0) + 0.5(0) + 0.25(0) + 0.5(0) + 1(1)+ 0.5(0) + 0.25(0) + 0.5(0) + 0.25(0) = 1

Shift right and repeat

0.25(0) + 0.5(0) + 0.25(0) + 0.5(1) + 1(0)+ 0.5(12) + 0.25(0) + 0.5(0) + 0.25(0) = 6.5

Note: Original values remain the same

Figure 4b. This is the upper left quadrant of the enlargement.

We start in the upper left quadrant (the yellow and green square) and centre the mask on the image value in the centre of the mask then we move to the green and blue square, and continue on in this manner.

Figure 4b shows how we add each result of an individual multiplication on the overlaid pixel. Notice that the operation has no affect on the original value but puts local averages in place of the zeroes.

Different values of the convolution mask will perform, as explained in the textbook, different effects.

To get acquainted with the Bitmap programs see the Tools section at the end of this lecture.

Colour

We learn about the basics of colour in our early physics classes but there is much more to colour than the discussion of its component parts. It is colours that confirm our assessment of the appearance of an object. If we are to successfully replicate objects in our websites or Multimedia productions we should understand how colour interacts with objects and how we interpret that interaction. As a production team member we must ensure consistency across our product and that means across the colours used. We are going to examine these issues in this part of the seminar.

The assessment of appearance is not only influenced by the geometry and colour of the region but also by our expectations. We deal with images presented to us by an opto-electronic system, however given the same sample; different systems will produce visually different images. This has many causes; from the variations in system components to the variability of viewing conditions. In the case of colour every observer will describe a colour based on their own experience of colour naming and their ability to discriminate colours. A simple means of ensuring that the observers are considering the same area is for all parties to be present and observing the same image. In a modern Multimedia development team, this is not practical; therefore, some time will elapse between consideration of the image by different people. In this case it is possible for the subsequent observer to fail to notice (or be incapable of noticing) a colour change or to misinterpret the extent of the particular colour changes under discussion. If a product should require further quality assurance examination then the differences in images may be sufficient to deny a successful assessment. The evaluation method chosen must therefore be precise and reproducible. This mandates a standardised set of conditions should be implemented. Particularly important aspects are lightsource spectral content, intensity, direction and also the viewpoint plus the imaging equipment. Some of these items, such as lighting direction and viewpoint are currently not controllable in 2D packages but the light intensity, spectral content, imaging and ambient viewing conditions are.

We are concerned with the reproducibility of colours with consistency and fidelity at the developer's monitor and the monitors of subsequent viewers after the image capture and processing stages. This will ensure repeatability when measurements are made. These concerns are dealt with by the appropriate Committee International d'Eclairage (CIE) standard. (The CIE is the recognised international standards body for colour.) A secondary concern is the effect of viewing conditions upon the perceived images. These are examined in this seminar and recommendations are made to aid in consistency of colour assessment.

We know that colour is a sensation produced because certain electromagnetic frequencies have a physiological effect, but what do we understand by appearance? For example, we talk of objects being 'glossy' without considering the precise nature of glossiness. This section will help define some descriptive terms and how they arise as object attributes. Appearance is determined not only by the geometry, colour and surroundings of an object but also by our subjective understanding of the nature of the object. Certain clues are missing or modified because we are always dealing with an image and not the object, i.e. Depth cues are distorted if we use wide angled lenses. The appearance of an object can be described by classifying them according to their effect on incident light. There are two further sub-divisions we can use to clarify this interaction. These are termed the colour and geometric attributes. Prior to looking at this classification, it is necessary to introduce some terminology.

The amount of specular reflection depends upon surface smoothness, the refractive index of the material, and the incident angle of the light. This produces what we term as glossiness. Non-metallic materials make little change to this reflected light so that a highlight is formed which is the same colour as the lightsource. If the surface is rough then this light is scattered and is added to the diffuse light. Thus, the diffuse light is modified by the lightsource colour, i.e. a white lightsource will cause the object to appear lighter in colour. Most of the light is refracted into the material where it encounters the pigment particles. Multiple reflections and refractions occur; thoroughly diffusing the light until it finally leaves the surface in all directions. This is known as diffusely reflected light. It is the refraction of the light into, and transmission from, the pigments that produces the colour. The spectral content of the light passing through the pigment is selectively absorbed thus producing colour. For example, a green pigment selectively absorbs blue and red.

Metal surfaces have negligible penetration by light and almost total reflection occurs producing their shiny appearance. Colour in metal is due to certain wavelengths being more efficiently reflected than others, e.g. Brass absorbs some blue wavelengths hence it has a yellowish appearance.

Translucent objects allow more light to pass through or to be transmitted than opaque materials hence their appearance owes more to diffuse transmission.

Finally, transparent objects allow almost all the incident light to be transmitted through the object.

Now we are in a position to characterise our objects:

a) Diffusing surfaces are those that possess surface colour. Their colour attributes come from diffuse reflection and their geometric attribute is glossiness from specular reflection. Their colour attributes are described in terms of lightness, hue and saturation.

b) Metallic Surfaces possess a colour attribute from specular reflection. They are described by their glossiness, hue and saturation. Their geometric attribute is a slight colour blurring due to surface diffusion.

c) Translucent objects have colour mainly from diffuse transmission. They possess colour attributes of translucency, hue and saturation and geometrically glossiness by specular reflection.

d) Transparent objects have colour from transmission. This is described in terms of clarity, hue and saturation. Geometrically there may be a slight blurring due to diffuse transmission.

The following paragraphs explain how we can maintain colour consistency across systems and how we may assess a given colour against another. This would be very important for example, if you were producing a multimedia product for a fashion house.
In order to assess colour systematically and consistently, it is necessary to quantitatively evaluate the light from the surface or object. Quantitative evaluation of light from objects is particularly important to manufacturing industries involved in presentation products. i.e. washing powders, paints, and much of the research is directed towards their needs. Test samples are usually made of flat uniform materials and the light is controlled to ensure stable test conditions. The light may be reflected or transmitted in a different manner for a given material depending upon the following:

a) The incident angle of the light.
b) The observer's viewpoint.
c) The spectral content of the lightsource.
d) The refractive indices of the materials constituents.

Two instruments are used to measure light leaving an object. The spectrophotometer measures light in terms of its constituent frequencies. The goniophotometer measures the quantity of light emitted in a particular direction. Both of these devices are used to produce data for comparison against known samples characteristics. When collecting this data it is necessary to control all the above parameters, a) to d), plus the following:

e) The intensity of the light source.
f) The angular size of the light source.
g) The spectral response functions of the observer.

Colour evaluations are made using a diffuse source with diffuse geometry whilst for gloss it requires a well-defined (possibly patterned) source.

From this data we can develop models of how materials modify light for inclusion in imaging light models. We can examine the items (a-g) above to see which it is possible to standardise or hold constant and from this develop a best practice. In photographic and film studio light sources, the intensity and spectral content are both controllable and controlled so that by recording their values at the time an image is taken we can provide transformations for other conditions. The angular size of the lightsource may be fixed or diffuse. Correction can be made to an image for poor light distribution provided the light type and value is recorded. The viewpoint of the observer is of concern when comparing samples e.g. for historical purposes, but is in practice uncontrollable. Computer processing can be enlisted in certain circumstances to change the viewpoint over small ranges.

The major characteristics of human vision are well known and can be found in any introductory text but their effect on fidelity of reproduction may not be obvious. This section looks at factors affecting our ability to assess the accuracy of the image both on the monitor and through any attached computer system.

The human eye can readily discriminate between 10 million juxtaposed surface colours, however, from memory, we can only manage to recall approximately 300. It is therefore, of primary importance that our image and the original are viewed together and as close to each other as possible if fidelity is to be achieved for a given sample. This is evidently not feasible. We must then resort to indirect means for colour and texture matching such as comparison against standard samples. In order to do this multiple monitors must be calibrated against the samples from time to time. A simple approach is to point the camera at a known sample, freeze the image and then compare the sample to the image. This is subject to gross errors that are covered in the text. An analytic approach is developed later.

The human eye functions most efficiently in daylight. Thus for maximum precision we should view our image and object at light levels consistent with daylight. This is possible for object-object comparisons but difficult for images due to the technology used. An equivalent approach is to ensure the spectral content of the lightsource and our viewing conditions are matched. With our light emitting screen technologies based on three chromaticities this implies matching the external light source to them and the monitors to each other.
Background distractions add coloured light to a scene and the recommendation is that they are removed and replaced with a neutral grey. This also helps with

chromatic induction and chromatic adaptation. Chromatic induction is the process whereby colour apparently changes due to preceding or surrounding visual stimulation. It has physiological causes due to gain changes in photoreceptors and polarisation of chromatic sites. The induced hue is approximately complementary to the inducing field. Chromatic adaptation is the ability of the eye to adapt to colour changes due to changes in illuminant. This leads to the concept of corresponding colours; sets of tristimulus values that describe the stimuli that evoke the same colour appearance under different conditions, eg. different light sources. The implication here is that we should control the ambient lighting conditions when viewing the monitor or a photograph.

We should discuss the lack of correlation between instrumentation and our eyesight. The tristimulus theory of colour reproduction has served well as an enabling methodology for the construction of the commonest imaging technologies however it has long been known that our vision sense is influenced by many other processes. The concept of colour opponent cells was first hinted at by Hering in 1878 and later developed by Mueller in 1930. This provides a more complete theory and explains our ability to notice small changes in hue at high saturation levels whilst requiring a greater relative change in saturation for a particular hue before it is noticed. Thus, it is noted that our eyes are not linear in their response to different stimuli. The tristimulus system represented by the RGB colour space has a linear basis so that other scales are required to deal effectively with colour differences. Typical of these are the CIELUV and CIELAB scales Our first difficulty; when describing the relationships between these scales mathematically is that we can only use approximating formulae. Implicitly instruments may not be able to produce (or describe) the colour required. The eye responds to factors external to our sample region of interest so that a measuring instrument may offer an accurate assessment based on recognised standards but we would still dispute their validity. Textured objects provide a further problem by distracting us from a clear colour assessment. They may also confuse instruments in a different sense thus producing larger apparent errors. The final point we must remember is that human perception is variable. Scales originate as collections of data from thousands of individuals and are not definitive of an individuals colour perception.

The monitor is easily the greatest contributor to variability of colour output. The ideal monitor would exhibit the following characteristics:

a) Phosphor Constancy. The spectral output would not be affected by the voltage applied.
b) Phosphor Independence. The output of a phosphor would not be affected by the output of other phosphors.
c) Spatial independence. The output of a given location would not be affected by the output at other locations.
d) Uniformity over time. The characteristics would not vary over time.

e) Spatial Uniformity. Output characteristics would be identical across the monitor face.

All of the above cannot be totally controlled which causes variability in images across monitors. There is little that can be done outside of improved quality to change items a)-d), Lack of spatial uniformity can be compensated for under program control. The calibration of monitors is necessitated by their temporal instability and is reviewed later.

Any monitor has a specific range of colours which are determined by the chromaticities of the CRT phosphors thus certain visual chromas are outside the realizable range. When different monitors are used to display the same image they will require matching to the original monitor. For an attached computer system the monitor differences are further complicated by the image capture system.

The device which isolates and captures an image for computer display is known as a scanner for 2D work and a frame grabber for video. This converts the incoming analogue signals to a digital format and is therefore limited in spectral bandwidth by quantization noise.

We will develop a method of matching the various system components throughout the remainder of this section. To begin with it is necessary to have some standard to which we can refer our subsequent analysis. The next section provides the relevant background.

Monitors are provided by different manufacturers each of whom strive to offer a superior specification. This may often be nothing more than an alternate specification. However all manufacturers provide equipment built to international standards and by using them as our baseline common ground may be established. The CIE have produced standard chromaticity diagrams against which various colour systems can be measured. The standard for monitors is the CIE 1931 2º Standard Observer chromaticity diagram.
The CIE standard chromaticity charts have several inadequacies. It should be noted that they are not a good choice for object descriptions since they refer to combinations of illuminant and object, nor do the CIE dimensions relate to perceived attributes of colours such as intensity. The CIE scales are linear and hence not uniform when visual spacing of colours is considered.. For an applet which shows the diagram see (Schaller, n.d.)

In the search for consistency and fidelity it is necessary to understand how an image may be degraded before we can determine corrective measures.

An important quantitative measure of performance in video equipment is the signal to noise ratio (s/n) ratio. This is often used as a measure of performance for analogue equipment. Noise is an unwanted, often random addition to the wanted signal level. For professional colour cameras a typical figure is 46 db's, or approximately a 3% disturbance to the wanted signal level. This type of degradation is cumulative throughout the analogue system which implies that at each stage in the system the input quality is fixed and any losses due to the previous stage become unrecoverable.

The process of degradation is described by taking each component of our system in turn.

In the camera the separate RGB signals are converted to composite video according to the local standard format i.e. NTSC, PAL, SECAM etc. There is a consequent reduction of chrominance bandwidth (NTSC being the worse) because of the historical necessity to provide compatibility with monochrome systems and international radio frequency bandwidth limitations for television channels from which the composite definitions were derived.

Issues such as radio frequency (RF) interference are considered negligible in our localised system since there are no broadcast requirements. Unfortunately every connection can lead to colour balance problems due to induced differences in electrical path length. The loss of high frequencies and hence part of the chrominance signal is also noticeable with increasing path lengths due to capacitive effects.

The video recorder losses are mostly due to the magnetic media. Magnetic media is good for digital storage but not for analogue storage due to its inherent non-linearity. For this reason the signal is modulated onto a fm carrier prior to storage. VHS, beta, and 8 mm formats all use a component system which separates the signal inside the recorder into luminance and chrominance channels. On replay the signals are recombined thus two stages are susceptible to losses in bandwidth and increased noise. Small tape size and low transport speed are further reasons for poor bandwidth.

A frame grabber is a source of sampling errors. No matter what number of bits per colour per pixel is chosen there will always be some quantisation error. This can increase artifacts produced by the analogue system. The simple solution is to capture images at the highest possible bits per pixel per colour available.

Images can be captures from digital cameras, screen captures and scanning of previously captured images (on film and books). For a tutorial on how to scan, which is an art by its own right, see (Fulton, n.d.) For a tutorial (one of many) on the use of digital cameras see (Curtin 2007).

The computer has the inherent ability to store information accurately and indefinitely. This allows us to say that the CPU is not a source of degradation however software file manipulations can be if the data is transformed between file formats into a different number of bits per colour. Therefore, it is necessary to store the data at the resolution of the frame-grabbed image.

The display system was originally designed for motion broadcast and compatibility with monochrome technology. This effectively fixed the channel bandwidth and the line rates for display on television monitors. Modern computer monitors have higher definition screens with associated electronics capable of greater fidelity if properly adjusted. The colour output is based on the phosphor chromaticities for a particular manufacturer's product. The monitors with greater colour range will have the widest spacing between their phosphor chromaticity values. Differences in these values between monitors causes them to produce different colours for the same input data if matching is not carried out.

The maintenance of fidelity and consistency within the chosen system is beyond the operators control except for insisting on regular maintenance checks. Regular checks should include a test chart to ensure correct focus is maintained and calibration of the lightsource intensity controls. Regular calibration must also be carried out on the monitors at least every six months. This ensures the monitor has known characteristics. Importantly, a known white point must be established which can then be used in determining transformation matrices between one monitor and another. This is done using a colorimeter, which compares a known white spot of light to the monitors white. These transformation matrices are the key to consistent reproduction. Given two monitors with known phosphor chromaticities (these can be measured but are usually available from the manufacturer), image data can be mapped from one system to the other so that the colours produced remain the same. This is achieved by mapping the monitors RGB space to the CIE space and then back into the other monitors RGB space.

The old standard for computerised image storage was eight bits per colour per pixel. This is true for the internet today. This is not sufficient for larger areas requiring subtle shading i.e. skin and flesh tones in close-ups, where artefacts such as mach banding become apparent. Quantization would ideally take place at 10 bits per primary to avoid our detecting such effects. There is a need for the associated computer graphics card to handle at least 24 bits per pixel if we are to maximise fidelity and consistency.

Image processing software requires an accurate lighting model with the attendant cost in computational time. Most common models do not adequately consider the materials characteristics. They take the lightsource as the primary factor in determining the resulting colour at a pixel and calculate contributions for three frequencies only i.e. RGB. For greater accuracy, we must more fully use the spectral curve data for both the lightsource and the material.   If we are to produce accurate models of real world objects then this computational cost must be accepted.

The maintenance of fidelity from the multimedia system viewpoint is easily summarized; you get what you pay for. There is no substitute for quality.

Certain problems cannot be overcome without the aid of image processing techniques. These may be incorporated in a package such as Photoshop. It is not sufficient to simply store the image, due consideration must be given to the format used. In particular, the format must also be capable of storing the monitor transformation matrix, the light source intensity and general system parameters. The TIFF standard is a representative example of a file format with the necessary capabilities as are the more common MPEG and JPEG standards.

We have already discussed the effects of chromatic induction and adaptation that help make the case for consistent viewing conditions. The modern multimedia system gives scant regard to the placement of the monitor beyond ease of viewing yet the ambient light affects the quality of the perceived image. The colour of an image on a monitor is diluted due to the specular diffusion of ambient light at the screen.. At higher light intensities, the screen appears white and impossible to use due to what is termed glare. This is a function of the viewers position with respect to the light sources. Several steps can be taken to minimise these effects. Firstly, the ambient light should be kept as low as possible consistent with working requirements. Secondly, the room should not admit light from external sources and ceiling lights should have parallel diffusers fitted. The spectral content of the lights should be as close to daylight as possible.

The manner in which the monitor is used can affect colour quality. Many high quality monitors use a CRT that contains a shadow mask. Due to thermal excitation by the electron beam the mask will expand or 'dome', this will cause colour shifts. It is therefore necessary that the monitor is switched on at least half an hour before use if colour comparisons are to be made. Finally, any monitor has greatest chromaticity range at low beam currents in the CRT. The brightness control should therefore be set as low as possible.

The consistency and fidelity of colour reproduction across systems can be achieved by adopting as a set of guidelines the recommendations in the preceding sections. These are listed below:

a) View images under standard conditions.
b) Ensure the monitors are calibrated regularly.
c) Switch on the monitor half an hour before use.
d) Store images in a flexible format such as TIFF.
e) Include with the image data; the light intensity, the matrix conversions, and the system data.

Certain problems are currently inescapable. These are;

the analogue front end, (Rapidly being resolved)
the CCD lens pixelation,
the display phosphors technology,
the age of the viewer.

Finally some recommendations for a cost effective system for colour analysis of images are offered. These are aimed at what can be reasonably achieved outside a professional image processing studio:

a) Use S-VHS or direct RGB (preferable) to the frame grabber
b) Sample at 24 bits or greater
c) Use a 24 bit frame buffer and do not re-sample for storage.
d) Display using the frame grabber definition
e) Purchase only good quality monitors and have them regularly calibrated.

The need for consistency and fidelity is greatest in picture analysis (i.e. colour edge detection), pattern matching, and picture archiving applications. This section has examined some of the problems and issues involved in reproducing accurate images and descriptions of surfaces. The means to attain consistency and fidelity have been discussed and some simple suggestions have been made with regard to best practice. In particular, the use of digital techniques where possible and the need for the highest sampling rates available are stressed.

We have come to the end of our seminar on bitmaps and colour. It has covered some very complex topics in as straightforward an approach as possible.

Links and References

Curtin D.P. (2007) A Short Course in using your Digital Camera [Internet]
http://www.shortcourses.com/using/index.htm
(Accessed: 15th September 2008)

Fulton W. (n.d.) A few scanning tips [Internet]
http://www.scantips.com/
(Accessed: 15th September 2008)

Schaller N.C.(n.d.) A CEI chromaticity applet [Internet]
http://www.cs.rit.edu/~ncs/color/a_chroma.html
(Accessed: 15th September 2008)

Tools:

Bitmap 2D:

Commercial: Photoshop, Photoshop Elements, Print Shop Pro
Bundles: Many. Simple editors are available with almost every digital camera.
Simple editors are found also in the Windows system (Paint and sometimes Photoed (more advanced))
Freeware:
Gimp (very advanced!): http://www.gimp.org/
Irfan, A very good viewer (not a manipulator): http://www.irfanview.com/

Colour:

Freeware: Pixie, a small program that analyzes colours:
http://www.nattyware.com/pixie.html
The CEI chromaticity applet, mentioned in the links, can also be downloaded as a program from the same site:
http://www.cs.rit.edu/~ncs/color/a_chroma.html