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NATIONAL OPEN UNIVERSITY OF NIGERIA

# CIT 742

## Multimedia Technology

## Module 3

# CIT 742 Multimedia Technology  Module 3

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# Module 3 Multimedia Data Representations

# Unit 1 Basics of Digital Audio

## 1.0 Introduction

In this module, we will focus on the theory of digitization, sampling and quantization. We will equally consider colour representation and the main role of the Adaptive Delta Pulse Code Modulation.

## 2.0 Objectives

At the end of this unit, you should be able to:

- explain the theory of digitization
- define the term 'sampling rate'
- list the typical audio formats
- describe the concept of colour representation
- identify the key role of the Adaptive Delta Pulse Code Modulation.

## 3.0 Main Content

### 3.1 The Theory of Digitization

Sound and image can be regarded as signals, in one or two dimensions, respectively. Sound can be described as a fluctuation of the acoustic pressure in time, while images are spatial distributions of values of luminance or color. Images can be described in their RGB (Red Green Blue) or HSB (Hue Saturation Value) components. Prior to processing signals by numerical computing devices, they have to be reduced to a sequence of discrete *samples*, and each sample must be represented using a finite number of bits. The first operation is called *sampling*, and the second operation is called *quantization* of the domain of real numbers.

### 3.2 Digitization of Sound

In order to gain a deeper understanding of the concept of digitizing, we would need to analyse what the term sound actually means:

- Sound is a continuous wave that travels through the air
- The wave is made up of pressure differences. Sound is detected by measuring the pressure level at a location.
- Sound waves have normal wave properties (reflection, refraction, diffraction, etc.).

- A variety of sound sources:

**Source**

- Generates Sound
- Air Pressure changes
- *Electrical* -- Loud Speaker
- *Acoustic* -- Direct Pressure Variations

The destination receives (sensed the sound wave pressure changes) and has to deal with accordingly:

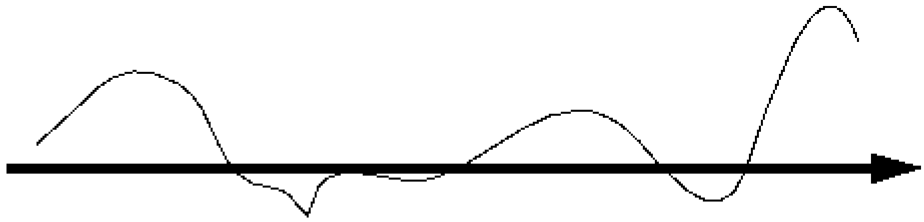
**Destination**

Receives Sound

- *Electrical* -- Microphone produces electric signal
- *Ears* -- Responds to pressure **hear** sound
- To input Sound into a computer: it needs to sampled or digitized;
- Microphones, video cameras produce *analog signals* (continuous-valued voltages) as illustrated in Fig 1


**Figure 1.0 Continuous Analog Waveform**

- To get audio or video into a computer, we have to *digitize* it (convert it into a stream of numbers) **Need to convert Analog-to-Digital** -- Specialised Hardware
- The sampling rate or sample rate is a term that defines the number of samples per second (or per other unit) taken from a continuous signal to make a discrete signal. For time-domain signals, it can be measured in samples per second (S/s), or hertz (Hz).
- *Quantization* - divide the vertical axis (signal strength) into pieces. Sometimes, a non-linear function is applied.
- 8 bit quantization divides the vertical axis into 256 levels. 16 bit gives you 65536 levels.




**Continuous Analog Waveform**

**Self-Assessment Exercise**

Explain the term ***'sampling rate'***

## 3.3 Typical Audio Formats

The typical audio formats are outlined below:

- Popular audio file formats include .au (Unix workstations), .aiff (MAC, SGI), .wav (PC, DEC workstations)

- A simple and widely used audio compression method is Adaptive Delta Pulse Code Modulation (ADPCM). Based on past samples, it predicts the next sample and encodes the difference between the actual value and the predicted value.

## 3.5 Colour Representations

Colour is the visual perceptual property corresponding in humans to the categories called red, yellow, blue and others. Colour derives from the spectrum of distribution of light energy versus wavelength interacting in the eye with the spectral sensitivities of the light receptors. Electromagnetic radiation is characterized by its wavelength (or frequency) and its intensity. When the wavelength is within the visible spectrum (the range of wavelengths humans can perceive, approximately from 380 nm to 740 nm), it is known as "visible light".

| Colour | Wavelength interval | Frequency interval |
|---|---|---|
| Red | ~700-635 nm | ~430-480 THz |
| Orange | ~635-590 nm | ~480-510 THz |
| Yellow | ~590-560 nm | ~510-540 THz |
| Green | ~560-490 nm | ~540-610 THz |
| Blue | ~490-450 nm | ~610-670 THz |
| Violet | ~450-400 nm | ~670-750 THz |

Table 3.1: Colours

Colour categories and physical specifications of colour are also associated with objects, materials, light sources, etc., based on their physical properties such as light absorption, reflection, or emission spectra. Colour space can be used as a model to identify colours numerically; for example, a colour can be specified by their unique RGB and HSV values.

## 4.0 Conclusion

Prior to processing signals by numerical computing devices, they have to be reduced to a sequence of discrete *samples* (***Sampling***), and each sample must be represented using a finite number of bits (***quantization of the domain of real numbers***). Popular audio file formats include .au (Unix workstations), .aiff (MAC, SGI), .wav (PC, DEC workstations).

## 5.0 Summary

This unit provided an overview of the theory of digitization, sources of sound, colour representation, sampling and quantization. We also considered typical audio formats, the main role of the Adaptive Delta Pulse Code Modulation. Hope you have found this unit enlightening.

## 6.0 Self-Assessment Exercise

1. Describe the concept of digitization

2. Identify 3 main sources of sound

3. List the typical audio formats

4. What is the key role of the Adaptive Delta Pulse Code Modulation?

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# Unit 2 Graphic/ Image Data Structure

## 1.0 Introduction

This unit presents the concept of pixels as well as some common graphics and image file formats. Some of them are restricted to particular hardware/operating system platforms; others are cross-platform independent formats. While not all formats are cross-platform, there are conversion applications that will recognize and translate formats from other systems.

## 2.0 Objectives

At the end of this unit, you should be able to:

- give a concise definition of pixel
- state the factor that determines the quality of a monitors' image
- discover typical image samples
- identify how pixels are stored in different images.

## 3.0 Main Content

### 3.1 Pixel

The word *pixel* is based on a contraction of *pix* ("pictures") and *el* (for "element"); thus a ***'pixel'*** refers to the smallest addressable screen element; it is the smallest unit of picture that can be controlled. Each pixel has its own address. The address of a pixel corresponds to its coordinates.

Pixels are normally arranged in a two-dimensional grid, and are often represented using dots or squares. Each pixel is a sample of an original image; more samples typically provide more accurate representations of the original. The intensity of each pixel is variable.

### 3.2 Monitor Resolution

A *digital image* consists of many picture elements (pixels). The number of pixels that compose a monitors' image determines the quality of the image (**resolution**). Higher resolution always yields better quality.

A ***bit-map*** representation stores the graphic/image data in the same manner that the computer monitor contents are stored in video memory.

### Self-Assessment Exercise

What factor determines a monitors' resolution?

## 3.3 Typical Image Samples

There are a wide range of images. However, for the purpose of this course, we will only consider the common images types.

### 3.3.1 Monochrome/ Bitmap Images

An example of a 1 bit monochrome image is illustrated in Fig.1 where:

**Sample Monochrome Bit-Map Image**

- Each pixel is stored as a single bit (0 or 1)
- A 640 x 480 monochrome image requires 37.5 KB of storage.
- Dithering is often used for displaying monochrome images

### 3.3.2 Grey-Scale Image

A common example of gray-scale image is illustrated in Fig 2 below:

**Example of a Gray-scale Bit-map Image**

- Each pixel is usually stored as a byte (value between 0 to 255)
- A 640 x 480 greyscale image requires over 300 KB of storage

### 3.3.3 8-bit Colour Images

An example of an 8-bit colour image is illustrated in Fig. 6.13 where:

**Example of 8-Bit Colour Image**

- One byte for each pixel
- Supports 256 out of the millions s possible, acceptable colour quality
- Requires Colour Look-Up Tables (LUTs)
- A 640 x 480 8-bit colour image requires 307.2 KB of storage (the same as 8-bit greyscale)

### 3.3.4 24-bit Colour Images

Base: I

An example 24-bit colour image is illustrated in Fig. 6.14 where:

**Example of 24-Bit Colour Image**

- Each pixel is represented by three bytes (e.g., RGB)
- Supports 256 x 256 x 256 possible combined colours (16,777,216)

- A 640 x 480 24-bit colour image would require 921.6 KB of storage
- Most 24-bit images are 32-bit images, the extra byte of data for each pixel is used to store an *alpha* value representing special effect information

## 4.0 Conclusion

To end, a ***'pixel'*** refers to the smallest addressable screen element. A *digital image* consists of many picture elements (pixels**)**. The number of pixels that compose a monitors' image determines the quality of the image (**resolution**). Popular image samples include: monochrome/bitmap image, grey-scale image, 8-bit colour image, 24-bit colour image etc.

## 5.0 Summary

This unit provided an overview of the notion of pixels, monitor resolution and typical sample images. We hope you found this unit enlightening.

## 6.0 Self-Assessment Exercise

1. Give a concise definition of pixel
2. State the factor that determines the quality of a monitors' image
3. List at least 4 common image samples
4. What is the relevance of dithering in the context bitmap images?
5. How are pixels depicted in 24-bit colour images?

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# Unit 3 Standard System Formats

## 1.0 Introduction

In the previous unit we examined pixels, the concept of monitor resolution and sample images. Here, we will be looking at system dependent and independent formats with a view to discovering their specific applications as well as drawbacks. Do make the most of your studies.

## 2.0 Objectives

At the end of this unit, you should be able to:

- identify popular system dependent formats
- state typical usage of the standard system independent formats.

## 3.0 Main Content

### 3.1 System Dependent Format

Many graphical/imaging applications create their own file format particular to the systems they are executed upon. The following are a few popular system dependent formats:

- Microsoft Windows: BMP
- Macintosh: PAINT and PICT
- X-windows: XBM

**System Independent Format**

The following brief format descriptions are the most commonly used standard system independent formats:

- GIF (GIF87a, GIF89a)
- JPEG
- TIFF
- Graphics Animation Files
- Postscript/Encapsulated Postscript

### GIF

GIF stands for Graphics Interchange Format (GIF) devised by the UNISYS Corp. and CompuServe. Originally used for transmitting graphical images over phone lines via modems.

This format uses the Lempel-Ziv Welch algorithm (a form of Huffman Coding), modified slightly for image scan line packets (line grouping of pixels). It is limited to only 8-bit (256) colour images, suitable for images with few distinctive colours (e.g., graphics drawing). It equally supports interlacing

## Self-Assessment Exercise

State one limitation and delimitation of GIF

### JPEG

- A standard for photographic image compression created by the Joint Photographics Experts Group
- Takes advantage of limitations in the human vision system to achieve high rates of compression
- Lossy compression which allows user to set the desired level of quality/compression.

### TIFF

- Tagged Image File Format (TIFF), stores many different types of images (e.g., monochrome, greyscale, 8-bit & 24-bit RGB, etc.) -> tagged
- Developed by the Aldus Corp. in the 1980's and later supported by the Microsoft
- TIFF is a lossless format (when not utilizing the new JPEG tag which allows for JPEG compression)
- It does not provide any major advantages over JPEG and is not user-controllable.
- It appears to be declining in popularity

### Graphic Animation Files

- FLC - main animation or moving picture file format, originally created by Animation Pro
- FLI - similar to FLC
- GL - better quality moving pictures, usually large file sizes

### Postscript/Encapsulated Postscript

- This is a typesetting language which includes text as well as vector/structured graphics and bit-mapped images

- Used in several popular graphics programs (Illustrator, FreeHand)
- Does not provide compression, files are often large

## 4.0 Conclusion

In conclusion, graphical/imaging applications create their own file format specific to the systems they are executed upon. Classical system dependent formats include; Microsoft Windows: BMP, Macintosh: PAINT and PICT, X-Windows: XBM. On the other hand, standard system independent formats include: GIF (GIF87a, GIF89a), JPEG, TIFF, Graphics Animation Files, and Postscript/Encapsulated Postscript.

## 5.0 Summary

We considered standard system dependent and independent formats. To test your knowledge, attempt the exercise below.

## 6.0 Self-Assessment Exercise

1.Explain the concept of system dependent format

2.List at least 3 popular system dependent formats

3.Which standard system independent format is best suited for photographic image compression?

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# Unit 4 Colour in Multimedia

## 1.0 Introduction

In this unit we will be learning about the fundamentals of colour in multimedia. We would also bring to light the benefits and challenges of using colour as well as the guidelines for using colour. Hope you would be able to grasp the key points.

## 2.0 Objectives

At the end of this unit, you should be able to:

- give a concise definition of colour
- explain the concept of spectrum of light
- discover the science of colours
- describe a visible light
- identify the similarity between the eye and a camera
- discover the benefits and challenges of using colour
- state the guidelines of using colour.

## 3.0 Main Content

### 3.1 Basics of Colour

**Colour** is the visual perceptual property corresponding in humans to the categories called red, green, blue and others. Colour derives from the ***spectrum*** of light (distribution of light energy versus wavelength) interacting in the eye with the spectral sensitivities of the light receptors.

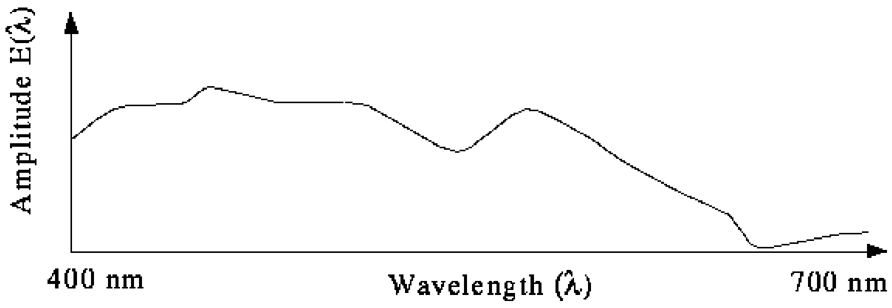
Color categories and physical specifications of color are also associated with objects, materials, light sources, etc., based on their physical properties such as light absorption, reflection, or emission spectra. By defining a color space, colors can be identified numerically by their coordinates.

Because perception of color stems from the varying sensitivity of different types of cone cells in the retina to different parts of the spectrum, colors may be defined and quantified by the degree to which they stimulate these cells. These physical or physiological quantifications of color, however, do not fully explain the psychophysical perception of color appearance.

The science of color is sometimes called ***chromatics***. It includes the perception of color by the human eye and brain, the origin of color in materials, color theory in art, and the physics of electromagnetic radiation in the visible range (that is, what we commonly refer to simply as light).

### 3.1.1 Light and Spectra

- Visible light is an electromagnetic wave in the range of 400nm - 700 nm.
- The light we often see is not a single wavelength; it is a combination of many wavelengths as depicted in the figure below.




**Light Wavelengths**

### 3.1.2 The Human Retina

- The eye is basically just like a camera
- Each neuron is either a *rod* or a *cone*. Rods are not sensitive to colour.

The functioning of a camera is often compared with the workings of the eye, mostly since both focus light from external objects in the visual field onto a light-sensitive medium. In the case of the camera, this medium is film or an electronic sensor; in the case of the eye, it is an array of visual receptors. With this simple geometrical similarity, based on the laws of optics, the eye functions as a transducer, as does a CCD camera.

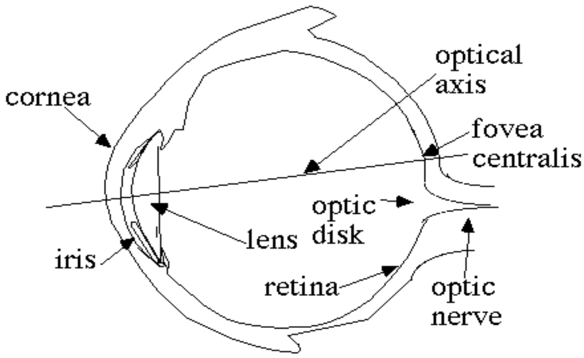
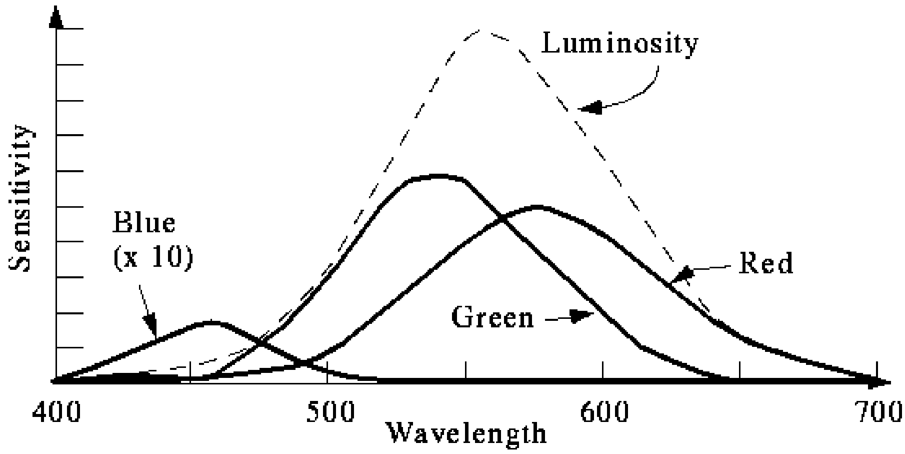



Figure 3.2: Human visual system

### 3.1.3 Cones and Perception

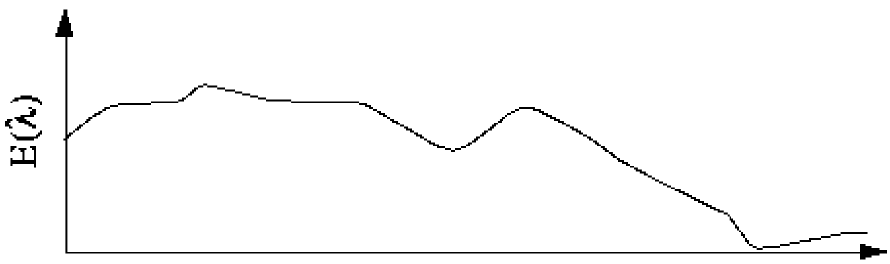
- Cones come in 3 types: red, green and blue. Each responds differently to various frequencies of light. The following figure shows the spectral-response functions of the cones and the luminous-efficiency function of the human eye.




**Cones and Luminous-efficiency Function of the Human Eye**

- The colour signal to the brain comes from the response of the 3 cones to the spectra being observed in the figure above. That is, the signal consists of 3 numbers:

$$R = \int E(\lambda)\, S_R(\lambda)\, d\lambda$$




Where *E* is the light and *S* are the sensitivity functions.

- A colour can be specified as the sum of three colours. So colours form a 3 dimensional vector space.

## Self-Assessment Exercise

Give an analogy between the human eye and a camera

## 3.2 Guidelines for Colour Usage

The main guidelines for colour are as follows:

1. Don't use too many colours. Shades of colour, greys, and pastel colours are often the best. Colour coding should be limited to no more than 5 to 7 different colours although highly trained users can cope with up to 11 shades.

2. Make sure the interface can be used without colour as many users have colour impairment. Colour coding should therefore be combined with other forms of coding such as shape, size or text labels.

3. Try to use colour only to categorize, differentiate and highlight, and not to give information, especially quantitative information.

### 3.3 Benefits and Challenges of Using Colour

Colour is important for effective display and hardware design. Colour is important for effective display and hardware design because it makes the screen layout attractive; may reduce users interpretation errors; emphasizes logical organisation of the information; and is very efficient at drawing the user's attention to a given part of the screen.

However, Colour is difficult to use correctly. The environment affects human colour perception e.g. lighting conditions may change the colours seen to less effective ones in display terms. Annoying after-images may be produced if a block of saturated colour is on display for a period of time. In addition, colour 'blindness' may significantly alter the appearance of a display for those affected by it, e.g. approximately 6% of men have difficulty distinguishing between shades of red and green.

## 4.0 Conclusion

In this unit, we discovered that colour derives from the ***spectrum*** of light interacting in the eye with the spectral sensitivities of the light receptors. We also learnt about chromatics, guidelines for using colour as well as the benefits and challenges of using colour.

## 5.0 Summary

This unit highlighted the rudiments of colour in multimedia. The benefits and challenges of using colour as well as the guidelines for using colour were equally presented. We hope you enjoyed your studies.

## 6.0 Self-Assessment Exercise

1. Give a concise definition of colour
2. Explain the concept of spectrum of light
3. Describe the term ‘chromatics’
4. State the guidelines of using colour

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