CIT742: MULTIMEDIA TECHNOLOGY
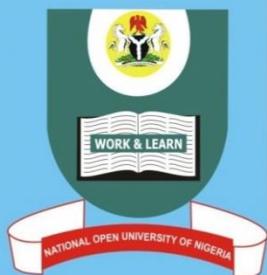
NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

COURSE CODE: CIT742

COURSE TITLE: MULTIMEDIA TECHNOLOGY

MAIN COURSE

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**COURSE
GUIDE**

**CIT742
MULTIMEDIA TECHNOLOGY**

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NATIONAL OPEN UNIVERSITY OF NIGERIA

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INTRODUCTION

CIT 742: Multimedia Technology is a two-credit unit course for students studying towards acquiring the Postgraduate Diploma in Information Technology and related disciplines.

The course is divided into four modules and 14 study units. It is aimed at giving the students a strong background on multimedia systems and applications. It gives an overview of the role and design of multimedia systems which incorporate digital audio, graphics and video, underlying concepts and representations of sound, pictures and video, data compression and transmission. This course equally covers the principles of multimedia authoring systems, source coding techniques, image histogram andprocessing.

At the end of this course, students should be able to describe the relevance and underlying infrastructure of the multimedia systems. They are equally expected to identify core multimedia technologies and standards (digital audio, graphics, video, VR, rudiments of multimedia compression and image histogram.

The course guide therefore gives you the general idea of what the course: CIT 742 is all about, the textbooks and other course materials to be referenced, what you are expected to know in each unit, and how to work through the course material. It suggests the general strategy to be adopted and also emphasises the need for self-assessment and tutor-marked assignment. There are also tutorial classes that are linked to this course and students are advised toattend.

WHAT YOU WILL LEARN IN THIS COURSE

The overall aim of this course, **CIT 742**, is to boost the expertise of students in handling multimedia systems. This course provides extensive multimedia applications and reference materials designed to augment your multimedia expertise. In the course of your studies, you will be equipped with definitions of common terms, characteristics and multimedia techniques.

COURSE AIM

This course aims to give students an in-depth understanding of multimedia systems technology, data representation and rudiments of multimedia compression and image histogram. It is hoped that the knowledge gained from this course would enhance students' proficiency in using multimedia applications.

COURSE OBJECTIVES

It is appropriate that students observe that each unit has precise objectives. They are expected to study them carefully before proceeding to subsequent units. Therefore, it may be useful to refer to these objectives in the course of your study of the unit to assess your progress. You should always look at the unit objectives after completing a unit. In this way, you would be certain that you have accomplished what is required of you by the end of the unit.

However, below are overall objectives of this course. On successful completion of this course, you should be able to:

• outline the development stages ofmultimedia
• give a concise definition ofmultimedia
• state typical applications ofmultimedia
• define the term'hypermedia'
• identify the difference between multimedia andhypertext
• give a concise definition ofmultimedia
• mention typical applications ofmultimedia
• define the term'hypermedia'
• differentiate between multimedia andhypertext
• itemise four characteristics of multimediasystems
• outline the components of multimediasystems
• describe the challenges for multimediasystems
• discuss the concept of an authoringsystem
• emphasise the significance of an authoringsystem
• examine the main authoringparadigms
• mention the authoring paradigm best suited for rapidprototyping
• state the correlation between iconic/flow control and frame authoringparadigm
• distinguish between discrete and continuousmedia
• explain the concept ofsynchronisation
• identify analog and digitalsignals
• state the common sources of text and staticdata
• describe the terms graphics andimages
• describe the common procedure for capturing audiosignals
• explain the concept of a rawvideo
• list output devices for a basic multimediasystem
• describe the common modes ofstorage
• identify the key issues I/Operformance
• state the difference between DVD-Video andDVD-ROM
• list the key components of a RAIDSystem
• discuss the storage parameters that affect how data isstored

- explain the theory ofdigitisation
- define the term 'samplingrate'
- list the typical audioformats
- describe the concept of colourrepresentation
- identify the key role of the Adaptive Delta Pulse Code Modulation
- give a concise definition ofpixel
- state the factor that determines the quality of a monitors'image
- know typical imagesamples
- identify how pixels are stored in differentimages
- explain the concept of system dependentformat
- list the popular system dependent formats
- identify the standard system independent format best suited for photographic imagecompression
- give a concise definition ofcolour
- explain the concept of spectrum oflight
- describe the term'chromatics'
- state the guidelines of using colour
- explain what transform codingis
- describe the notion of losslesscompression
- identify typical applications of lossy and losslesscompression
- discover how images are represented in the different forms of encoding
- identify the basic lossy compressionschemes
- state the significance of Fouriertransform
- show the link between Fourier series coefficient and discreet cosine transformcoefficient
- give a concise description of the discrete time Fouriertransform
- list the common image-codingstandards
- explain the properties of the two dimensional Fouriertransform
- explain the principle of videocompression
- describe the JPEG algorithmapproach
- explain the application of videocompression
- discover the sensitivity of humanhearing
- describe the notion ofpsychoacoustics
- describe the concept of the histogram of animage
- give an overview of imageanalysis
- identify a bi-modalimage
- mention two main image enhancementoperators
- explain the notion of imagerestoration
- define the term'noise'.

WORKING THROUGH THIS COURSE

To complete this course, you are required to study all the units, the recommended text books, and other relevant materials. Each unit contains some self-assessment exercises and tutor-marked assignments, and at some point in this course, you are required to submit the tutor-marked assignments. There is also a final examination at the end of this course. Stated below are the components of this course and what you have to do.

COURSE MATERIALS

The major components of the course are:

1. CourseGuide
2. Study Units
3. Text Books andReferences
4. Assignment File
5. PresentationSchedule

STUDY UNITS

There are 14 study units integrated into 4 modules in this course. Theyare:

Module1   Introduction toMultimedia

Unit 1   Fundamentals of Multimedia
Unit 2   MultimediaSystems
Unit 3   Multimedia AuthoringSystem

Module2   Multimedia SystemsTechnology

Unit 1   Media andSignals
Unit 2   Media Sources and Storage Requirements
Unit 3   Output Devices and StorageMedia

Module 3   Multimedia DataRepresentations

Unit 1   Basics of Digital Audio
Unit 2   Graphics/Image File Format
Unit 3   Standard System Formats
Unit 4   Colour in Multimedia

Module4   MultimediaCompression

Unit 1   Rudiments of MultimediaCompression
Unit 2   Source CodingTechniques
Unit 3   Video and Audio Compression
Unit 4   Image Histogram andProcessing

TEXTBOOKS AND REFERENCES

The following books are highly recommended as complement for other materials highlighted in this course:

Zeng, B., El-Saddik, A., Fan, X., Huang, Q., Jiang, S. and Li, H. (Eds.). (2017). Advances in multimedia information processing --- PCM 2017. Springer international publishing

Shi, Y. and Sun, H. (2019). Image and Video Compression for Multimedia Engineering: Fundamentals,Algorithms and Standards. Taylor & Francis Group

Stankovic, S., Sejdic, E., and Orovic, I. (2016). Multimedia Signals and Systems: Basic and Advanced Algorithms for signal processing (2nd edition). Springer International Publishing.
Ohm, J. (2015). Multimedia signal coding and transmission. Spring street, NY. Springer
Karrenberg, U. (2013). Signals, processes and systems; *an interactive multimedia introduction to signal processing* (3rd edition). Spring street, NY. Springer

Stankovic, S., Sejdic, E., and Orovic, I. (2012). Multimedia signals and systems. Spring street, NY. Springer

Li Z., Drew M.S and Liu J (2014). Fundamentals of Multimedia (2nd edition). Sprinnger Cham Heidelberg, New York London, Prentice-Hall

Lovely Professional University (2013). Multimedia Systems. Rajneesh Agrawal. Excel Books Private Limited.

Tsihrintzis G.A.,Virvou and M.,Jain L.C (2013). Multimedia Services in Intelligient Environments: Advances in recommender systems. Springer International Publishing

Pande A and Zambreno J (2013). Embedded Multimedia Security Systems: Algorithms and Architectures. Springer-Verlag London

Veena M.N, Vasudev T., Swamy P.P. and Guru D.S (2013). Multimedia Processing, Communication and Computing Applications: Proceedings of the First International Conference, ICMCCA. Springer India

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Rao K.R., Bojkovic Z.S and Bakmaz B.M (2014). Wireless Multimedia Communication Systems: Design, Analysis, and Implementation. CRC Press.

Ho Y (2013). Advance Video Coding for Next-Generation Multimedia Services. Intech

Lisowska A, Park J.J., Ng J.K., Jeong H.Y and Waluyo B (2013). Multimedia and Ubiquitous Engineering: MUE 2013. Springer Netherlands.

Karrenberg, U. (2013). Signals, processes and systems; *an interactive multimedia introduction to signal processing* (3rd edition). Spring street, NY. Springer

Ohm, J. (2015). *Multimedia signal coding and transmission*. Spring street, NY. Springer

Analog vs. Digital. https://learn.sparkfun.com/tutorials/analog-vs-digital/all

Multimedia Systems. https://www.tutorialspoint.com/multimedia/multimedia_systems.htm

ASSIGNMENT FILE

The assignment file will be given to you in due course. In this file, you will find all the details of the work you must submit to your tutor for marking. The marks you obtain for these assignments will count towards the final mark for the course. In sum, there are 14 tutor-marked assignments for this course.

PRESENTATION SCHEDULE

The presentation schedule included in this course guide provides you with important dates for completion of each tutor-marked assignment. You should therefore endeavour to meet the deadlines.

ASSESSMENT

There are two aspects to the assessment of this course. First, there are tutor-marked assignments; and second, the written examination.

Therefore, you are expected to take note of the facts, information and problem solving gathered during the course. The tutor-marked assignments must be submitted to your tutor for formal assessment, in accordance to the deadline given. The work submitted will count for 40% of your total coursemark.

At the end of the course, you will need to sit for a final written examination. This examination will account for 60% of your total score.

TUTOR-MARKED ASSIGNMENTS (TMA)

There are 14 TMAs in this course. You need to submit all the TMAs. The best four will therefore be counted. When you have completed each assignment, send them to your tutor as soon as possible and makecertain that it gets to your tutor on or before the stipulated deadline. If for any reason you cannot complete your assignment on time, contact your tutor before the assignment is due to discuss the possibility of extension. Extension will not be granted after the deadline, unless on extraordinarycases.

FINAL EXAMINATION AND GRADING

The final examination for CIT 742 will be of last for a period of three hours and have a value of 60% of the total course grade. The examination will consist of questions which reflect the self-assessment exercise and tutor-marked assignments that you have previously encountered. Furthermore, all areas of the course will be examined. It would be better to use the time between finishing the last unit and sitting for the examination, to revise the entire course. You might find it useful to review your TMAs and comment on them before the examination. The final examination covers information from all parts of thecourse.

COURSE MARKING SCHEME

The following table includes the course marking scheme

Table 1: Course Marking Scheme

Assessment	Marks
Assignments 1-14	14 assignments, 40% for the best 4 Total = 10% X 4 = 40%
Final Examination	60% of overall course marks
Total	100% of Course Marks

COURSE OVERVIEW

This table indicates the units, the number of weeks required to complete them and the assignments.

Table 2: Course Organiser

Unit	Title of Work	Weeks Activity	Assessment (End of Unit)
	Course Guide	Week 1	
Module 1	**Introduction to Multimedia**		
Unit 1	Fundamentals of Multimedia	Week 1	Assignment 1
Unit 2	Multimedia Systems	Week 2	Assignment 2
Unit 3	Multimedia Authoring Tools	Week 3	Assignment 3
Module 2	**Multimedia Systems Technology**		
Unit 1	Media and Signals	Week 4	Assignment 4
Unit 2	Media Sources and Storage Requirements	Week 5	Assignment 5
Unit 3	Output Devices and Storage Media	Week 6	Assignment 6
Module 3	**Multimedia Data Representation**		
Unit 1	Basics of Digital Audio	Week 7	Assignment 7
Unit 2	Graphics/Image File Format	Week 7	Assignment 8
Unit 3	Standard System Formats	Week 8	Assignment 9
Unit 4	Colour in Multimedia	Week 9	Assignment 10
Module 4	**Multimedia Compression**		
Unit 1	Rudiments of Multimedia Compression	Week 10	Assignment 11
Unit 2	Source Coding Techniques	Week 11	Assignment 12
Unit 3	Video and Audio Compression	Week 12	Assignment 13
Unit 4	Image Histogram and Processing	Week 13	Assignment 14

HOW TO GET THE MOST OUT OF THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the huge advantages of distance learning mode; you can read and work through specially designed study materials at your own pace and at a time and place that is most convenient. Think of it as reading from the teacher, the study guide indicates what you ought to study, how to study it and the relevant texts to consult. You are provided with

exercises at appropriate points, just as a lecturer might give you an in-class exercise.

Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next to this is a set of learning objectives. These learning objectives are meant to guide your studies. The moment a unit is finished, you must go back and check whether you have achieved the objectives. If this is made a habit, then you will increase your chances of passing the course. The main body of the units also guides you through the required readings from other sources. This will usually be either from a set book or from other sources.

Self-assessment exercises are provided throughout the unit, to aid personal studies and answers are provided at the end of the unit. Working through these self tests will help you to achieve the objectives of the unit and also prepare you for tutor-marked assignments and examinations. You should attempt each self test as you encounter them in theunits.

The following are practical strategies for working through this course

1. Read the course guidethoroughly.
2. Organise a study schedule. Refer to the course overview for more details. Note the time you are expected to spend on each unit and how the assignment relates to the units. Important details, e.g. details of your tutorials and the date of the first day of the semester are available. You need to gather together all these information in one place such as a diary, a wall chart calendar or an organiser. Whatever method you choose, you should decide on and write in your own dates for working on eachunit.
3. Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is thatthey get behind with their course works. If you get into difficulties with your schedule, please let your tutor know before it is too late tohelp.
4. Turn to Unit 1 and read the introduction and the objectives for the unit.
5. Assemble the study materials. Information about what you need for a unit is given in the table of content at the beginning of each unit. You will almost always need both the study unit you are working on and one of the materials recommended for further readings, on your desk at the sametime.

6. Work through the unit, the content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit, you will be encouraged to read from your set books.
7. Keep in mind that you will learn a lot by doing all your assignments carefully. They have been designed to help you meet the objectives of the course and will help you pass theexamination.
8. Review the objectives of each study unit to confirm that you have achieved them. If you are not certain about any of the objectives, review the study material and consult yourtutor.
9. When you are confident that you have achieved a unit's objectives, you can start on the next unit. Proceed unit by unit through the course and try to pace your study so that you can keep yourself on schedule.
10. When you have submitted an assignment to your tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments, both on the tutor-marked assignment form and also written on the assignment. Consult your tutor as soon as possible if you have any questions orproblems.
11. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this courseguide).

FACILITATION/TUTORS AND TUTORIALS

There are eight hours of tutorial provided in support of this course. You will be notified of the dates, time and location together with the name and phone number of your tutor as soon as you are allocated a tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter and provide assistance to you during the course. You must mail your tutor marked assignment to your tutor well before the due date. At least two working days are required for this purpose. They will be marked by your tutor and returned to you as soon as possible.

Do not hesitate to contact your tutor by telephone, e-mail or discussion board if you need help. The following might be circumstances in which you would find help necessary: contact your tutor if:

- you do not understand any part of the study units or the assigned readings
- you have difficulty with the self-test orexercise

- you have questions or problems with an assignment, with your tutor's comments on an assignment or with the grading of an assignment.

You should try your best to attend the tutorials. This is the only chance to have face-to- face contact with your tutor and ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit from the course tutorials, prepare a question list before attending them. You will learn a lot from participating in discussion actively. Do have a pleasant discovery!

MODULE1   INTRODUCTION TOMULTIMEDIA

Unit 1   Fundamentals of Multimedia
Unit 2   MultimediaSystems
Unit 3   Multimedia AuthoringSystem

UNIT 1   FUNDAMENTALS OFMULTIMEDIA

CONTENTS

1.0   Introduction
2.0   Intended Learning Outcomes (ILOs)
3.0   Main Content
    3.1   History ofMultimedia
    3.2   Multimedia andHypermedia
        3.2.1   What isMultimedia?
        3.2.2   MultimediaApplication
        3.2.3   Hypertext
        3.2.4   Hypermedia
4.0   Self-Assessment Exercise(s)
5.0   Conclusion
6.0   Summary
7.0   FurtherReadings

1.0   Introduction

This unit is designed to introduce you to multimedia basics. It provides an overview of the essential aspects of multimedia. It equally highlights the link between hypertext and hypermedia.

Thus, it is recommended that you go through the entire module systematically to gain some insight of the course.

2.0   Intended Learning Outcomes (ILOs)

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

- outline the development stages ofmultimedia
- give a concise definition ofmultimedia
- state typical applications ofmultimedia
- define the term'hypermedia'
- differentiate between multimedia andhypertext.

3.0   MainContent

3.1   History ofMultimedia

The term "multimedia" was first coined by Bob Goldstein to promote the July 1966 opening of his "LightWorks at L'Oursin" show at Southampton, Long Island. On August 10, 1966, Richard Albarino borrowed the terminology, reporting: "Brainchild of songscribe-comic". Two years later, in 1968, the term "multimedia" was re-appropriated to describe the work of a political consultant, David Sawyer, the husband of Iris Sawyer—one of Goldstein's producers atL'Oursin.

In the late 1970s the term was used to describe presentations consisting of multi-projector slide shows timed to an audio track. However, by the 1990s 'multimedia' took on its current meaning.

In the 1993 first edition of McGraw-Hill's *Multimedia: Making It Work*, Tay Vaughan declared, "Multimedia is any combination of text, graphic art, sound, animation, and video that is delivered by computer. When you allow the user – the viewer of the project – to control what and when these elements are delivered, it is *interactive multimedia*. When you provide a structure of linked elements through which the user can navigate, interactive multimedia becomes*hypermedia*."

Subsequently, the German language society, Gesellschaft für deutsche Sprache, decided to recognise the word's significance and ubiquitousness in the 1990s by awarding it the title of 'Word of the Year' in 1995. The institute summed up its rationale by stating "[Multimedia] has become a central word in the wonderful new mediaworld".

In common usage, the term multimedia refers to an electronically delivered combination of media including video, still images, audio, text in such a way that can be accessed interactively. Much of the content on the web today falls within this definition as understood by millions. Some computers which were marketed in the 1990s were called "multimedia" computers because they incorporated a CD-ROM drive, which allowed for the delivery of several hundred megabytes of video, picture, and audio data.

3.2   Multimedia andHypermedia

In order to be effective in this digital age, one needs to understand two key technological terms used virtually in all facets of life - ***multimedia*** and ***hypermedia***. In practical terms, when someone turns on a computer, puts a compact disc (CD) in its CD drive, and listens to her favorite music while she works on a paper, she is experiencing multimedia.

Other examples of multimedia usage include looking at pictures taken from a digital camera.

In contrast, surfing the World Wide Web, following links from one site to another, looking for all types of information, is called experiencing hypermedia. The major difference between multimedia and hypermedia is that the user is more actively involved in the hypermedia experience, whereas the multimedia experience is more passive.

3.2.1 What isMultimedia?

Several authors have depicted multimedia in different ways. Essentially, it can be described as the integration of sound, animation, and digitised video with more traditional types of data such as text. It is an application-oriented technology that is used in a variety of ways, for example, to enhance presentations, and is based on the increasing capability of computers to store, transmit, and present many types of information.

A good general definition is:

Multimedia is the field concerned with the computer-controlled integration of text, graphics, drawings, still and moving images (Video), animation, audio, and any other media where every type of information can be represented, stored, transmitted and processed digitally.

Components of Multimedia

The various modalities of text, video, audio, images, animation, audio and so on are put to use in multimedia in different forms such as:

- Geographically based, real-time augmented-reality, massively multiplayer online video games, making use of any portable device such as smartphones, laptops, or tablets, which function as GPS-aware mobile game consoles.
- Shapeshifting TV, where viewers vote on the plot path by phone text-messages, which are parsed to direct plot changes in real-time.
- A camera that predicts what would be the best type of next shot so as to conform to ideal principle for developing storyboards.
- A Web-based video editor that allows one create a new video by editing, annotating, and remixing professional videos on the cloud.
- Collaborative education environments that allow school-children to share a single educational game using two mice at once that pass control back and forth.
- Searching (very) large video and image databases for target

visual objects, using semantics of objects.

- Merging of artificial and natural video into hybrid scenes, placing real-appearing computer graphics and video objects into scenes so as to take the physics of objects and lights (e.g., shadows) into account.
- Visual cues of video-conference participants, taking into account gaze direction and attention of participants.
- Making multimedia components editable—allowing the user side to decide what components, video, graphics, and soon are actually viewed and allowing the client to move components around or delete them—making components distributed.
- Building "inverse-Hollywood" applications that can recreate the process by which a video was made, allowing storyboard pruning and concise video summarization.

3.2.2 Multimedia Application

A *Multimedia Application* is an Application which uses a collection of multiple media sources e.g. text, graphics, images, sound/audio, animation and/or video. Hypermedia can be considered as one of the multimedia applications. Some examples of multimedia applications are: business presentations, online newspapers, distance education, and interactive gaming, advertisements, art, entertainment, engineering, medicine, mathematics, business, scientific research and spatial temporalapplications.

Other examples of Multimedia Applications include:

- World WideWeb
- Hypermedia courseware
- Videoconferencing
- Video-on-demand
- InteractiveTV
- Groupware
- Homeshopping

- Games
- Virtual reality
- Digital video editing and productionsystems
- Multimedia Databasesystems

3.2.3 Hypertext

Typically, a Hypertext refers to a text which contains links to other texts. The term was invented by Ted Nelson around 1965. Hypertext is therefore usually non-linear (as indicated below).
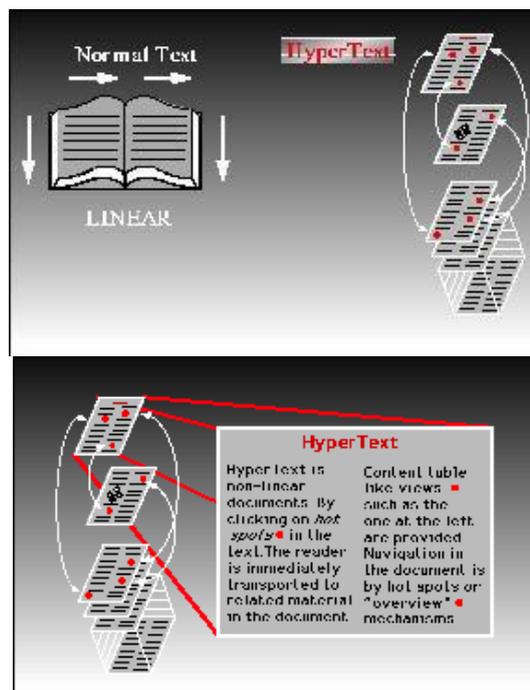

Fig. 1.1: Hypertext

In 1990, Tim Berners-Lee proposed the World Wide Web to CERN (European Center for Nuclear Research) with aim of achieving collaboration in organizing and sharing of research work and experimental results. Development of hypertext server, browser and editor on a NeXTstep workstation started immediately after the approval of his proposal by CERN. Hence, the advent of Hypertext Markup Language (HTML) and the Hypertext Transfer Protocol (HTTP) from his team.

Hypertext Markup Language (HTML)

Charles Goldfarb, Edward Mosher, and Raymond Lorie developed a Generalized Markup Language (GML) for IBM, with the intention of introducing formats that should be human-readable and able to identify structure and elements. In the year 1986, came the final version of the Standard Generalized Markup Language (SGML) was released by the ISO and it was mostly based on the earlier GML.

HTML is defined using SGML and is a language for publishing hypermedia on the web. It uses ASCII format which makes it compatible with different computer hardware and this makes it acceptable for global exchange of information. The current version of HTML is HTML5 developed in 2019.

HTML is designed to use tags in order to describe document elements. The tags are in the format

<token params> to define the start point of a document element and </token> to define the end of the element. Some elements have only inline parameters and do not require ending tags. HTML divides the document into a HEAD and a BODY part as shown below:

<HTML>

<HEAD>
   ...

</HEAD>

<BODY>
   ...

</BODY>

</HTML>

The HEAD tag, describes document definitions and this may include page title, resources links and meta-information the author decides to specify. The body part describes the document structure and content.

3.2.4 Hypermedia

HyperMedia is not constrained to be text-based. It is an enhancement of hypertext, the non-sequential access of text documents, using a multimedia environment and providing users the flexibility to select which document they want to view next, based on their current interests. The path followed to get from document to document changes from user to user and is very dynamic. It can include other media, e.g., graphics, images, and especially the continuous media - sound and video. Apparently, Ted Nelson was also the first to use this term.
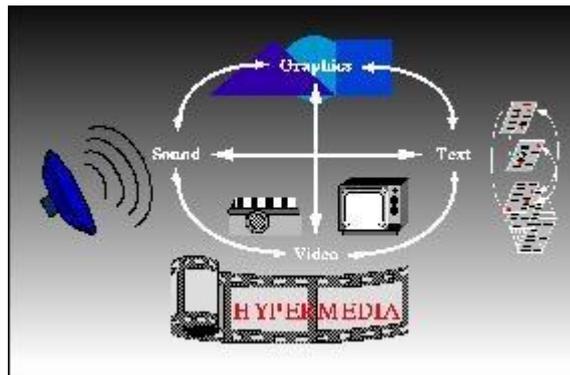
Fig. 1.2: Hypermedia

The World Wide Web (WWW) is the best example of hypermedia applications.

4.0 Self-Assessment Exercise(s)

State the main distinction between multimedia and hypermedia.

_____
_____
_____
_____

5.0   Conclusion

In this unit, we highlighted the development stages of multimedia and described the terms- multimedia, hypertext and hypermedia. We equally considered the multimedia applications as well as the relevance of multimedia and hypermedia.

6.0   Summary

This unit provided an overview of the history of multimedia; description of multimedia, hypertext and hypermedia. Now, let us attempt the questions below.

7.0   FurtherReadings

Zeng, B., El-Saddik, A., Fan, X., Huang, Q., Jiang, S. and Li, H. (Eds.). (2017). Advances in multimedia information processing --- PCM 2017. Springer international publishing

Shi, Y. and Sun, H. (2019). Image and Video Compression for Multimedia Engineering: Fundamentals,Algorithms and Standards. Taylor & Francis Group

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Ohm, J. (2015). *Multimedia signal coding and transmission*. Spring street, NY. Springer

Analog vs. Digital (n.d). https://learn.sparkfun.com/tutorials/analog-vs-digital/all

Multimedia Systems (n.d). https://www.tutorialspoint.com/multimedia/multimedia_systems.htm

UNIT 2   MULTIMEDIASYSTEMS

CONTENTS

1.0   Introduction

In unit 1, we gave an overview of fundamentals of multimedia and multimedia applications. This unit provides information about multimedia systems.

2.0   Intended Learning Outcomes (ILOs)

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

- identify four characteristics of multimediasystems
- outline the components of multimediasystems
- describe the challenges for multimediasystems.

3.0   MainContent

3.1   Characteristics of a MultimediaSystem

Basically, a Multimedia system has four vital characteristics:

- multimedia systems must be ***computercontrolled***
- multimedia systems are***integrated***
- the information they handle must be represented***digitally***
- theinterfacetothefinalpresentationofmediaisusually ***interactive***

3.2   Challenges for MultimediaSystems

Multimedia systems may have to render a variety of media at the same instant -- a distinction from normal applications. There is a temporal

relationship between many forms of media (*e.g.* Video and Audio). Multimedia systems are often required for:

- **Sequencing within the media** -- *playing frames in correct order/time frame invideo*
- *Synchronisation* -- inter-media scheduling (*e.g.* Video and Audio). Lip synchronisation is clearly important for humans to watch playback of video and audio and even animation and audio. Ever tried watching an out of (lip) sync film for a long time?

Hence, the key issues multimedia systems need to deal with here are:

- how to represent and store temporalinformation
- how to strictly maintain the temporal relationships on play back/retrieval
- what are the processes involved in tackling theseissues?

Another challenge is that the initial forms of data have to be represented *digitally, i.e.* translated from the analog source to the digital representation. The will involve scanning (graphics, still images), sampling (audio/video) although digital cameras now exist for direct scene to digital capture of images and video.

3.3   Desirable Features for a MultimediaSystem

Haven discovered the challenges that have to be surmounted in using multimedia systems; the following features are desirable for a Multimedia System:

- **Very High Processing Power:** This is a requirement for dealing with large data processing and real time delivery ofmedia.
- **Multimedia Capable File System:** This feature is essential for delivering real-time media -- *e.g.* Video/Audio Streaming. Special Hardware/Software needed *e.g.* RAIDtechnology.
- **Data Representations/File Formats that support multimedia:** Data representations/file formats should be easy to handle yet allow for compression/decompression inreal-time.
- **Efficient and High I/O:** Input and output to the file subsystem needs to be efficient and fast. It is necessary to allow for real-time recording as well as playback of data. *e.g.* Direct to Disk recordingsystems.
- **Special Operating System:** A special operating system is required to provide access to file system and process data efficiently and quickly. Consequently, the multimediasystem

needs to support direct transfers to disk, real-time scheduling, fast interrupt processing, I/O streaming *etc.*

- **StorageandMemory:**Largestorageunits(oftheorderof50 -100 Gb or more) and large memory (50 -100 Mb or more). Large Caches also required and frequently of Level 2 and 3 hierarchy for efficientmanagement.

- **Network Support:** Client-server systems commonly known as distributed systems.

- **Software Tools:** User friendly tools are needed to handle media, design and develop applications, delivermedia.

3.4   Components of a MultimediaSystem

We can now consider the core components required for a multimedia system:

Capturedevices	-- Video Camera, VideoRecorder, Audio Microphone, Keyboards, mice, graphics tablets, 3D input devices, tactile sensors, VR devices. Digitising/Sampling Hardware
StorageDevices	-- Hard disks, CD-ROMs,Jaz/Zip drives, DVD, *etc*
Communication Networks	-- Ethernet, Token Ring, FDDI, ATM, Intranets, Internets.
ComputerSystems	-- Multimedia Desktopmachines, Workstations, MPEG/VIDEO/DSP Hardware
DisplayDevices	-- CD-quality speakers,HDTV,SVGA, Hi-Res monitors, Colour printers *etc.*

3.5 Stages of Multimedia Project

There are basically three stages of multimedia project namely:
- Pre-production
- Production
- Post-production

The order of these stages are very important. It is advisable for every member of the project team to agree before the beginning of the project, what should be done and why it is necessary to do it. Lack of proper agreement among team members could lead to uncompleted project when started. Hence, the reason for the clarification of why, what the multimedia product has to offer in order to fulfil the needed purpose. It is the "why" and "what" that determines the decisions centering around storyboard, flow chart, media content and so on.

Pre-production – this is the process before producing multimedia project. The following are stages of the pre-production process.

Idea or Motivation

It is important that the question of "why" is used as a source of motivation for the multimedia project. The first question from the production team should be "why" the multimedia project needs to be embarked on. Other expected questions should be:

- Is the idea marketable and profitable?
- Is multimedia the best option, or would a print production be more effective?

Production Concept and Project Goals

This stage of pre-production requires lots of brainstorming sessions in order to come up with an idea. It is until the idea has be crystalized that the production team can figure out the market benefit of the multimedia product.Activities such as developing a planning document, interviewing the client and building specifications for production should be able to guide on what information and function the team need to provide in order to meet the desire goals.

Target Audience

It is important that the background of the target audience is being considered in order to implement the best structure that will fit in accordingly in the multimedia project. This consideration will help figure out the special interest groups to which the project might be targeted towards and the nature of information the group may deem very necessary.

Delivery medium and authoring tools

The project team in this phase, has to decide the best medium to reach out to their audience. This can be decided by determining the available equipment of the target audience and the expected obstacles to be overcome. Some of the commonly used delivery medium are as follows: Web, DVDs and CD-ROMs. Also, a few authoring tools that are mostly being used by production team are: Graphics, audio, video, text, animation and so on.

Planning

This stage is very important to the very success of any multimedia project. The project team works together to decide the appearance and deliverable of the project. Some of the questions usually encountered in planning are as follows:

- What do you require for the multimedia project?
- How long will each task take?
- Who is going to do the work?
- How much will the product cost?

Planning is inclusive of creating and finalizing flowchart and resource organization in which the product's content is arranged into groups, establishing timeline, content list, storyboard, finalizing the functional specifications and work assignments.

Production

It is at this stage that all components of planning come to effect. A well planned pre-production, will result to proper coordination of the team individuals in performing their role accordingly.   In this phase, graphic artists, instructional designers, animators, audiographers and videographers starts the creation of the artwork, animation, scripts, video, audio and interface. The production phase is always successful when the project manager has distributed roles accordingly to the right individuals and created practical and achievable production schedule.   Some of the things expected from people involved in production are as follows:

Scriptwriting

The scripts for the text, transitions, audio narrations, voice-overs and video are written. Existing material also needs to be rewritten and reorganized for an electronic medium. Then the written material is edited for readability, grammar and consistency.

Art

Illustrations, graphics, buttons, and icons are created using the prototype screens as a guide. Existing photographs, illustrations, and graphics are digitized for use in an electronic medium.

3D Modelling and Animation

The 3D artwork is created, rendered, and then prepared for use in the authoring tool. The 3D animations require their own storyboards and schedules.

Authoring

All the pieces come together in the authoring tool. Functionality is programmed, and 2D animation is developed. From here, the final working product is created. Every word on the screen is proofread and checked for consistency of formatting. In addition, the proofreader reviews all video and audio against the edited scripts.

Shooting and Recording Digitizing Video

The edited scripts are used to plan the budget, performers, time schedules and budget, then the shoot is scheduled followed by recording.

Quality Control

Quality control goes on throughout the process. The storyboards are helpful for checking the sequencing.

Post-production

In this stage of the project, it is important to address the post-production technicalities in order to produce a perfect and error free project. It is one of the most fundamental of all stages of production. The stage of post-production includes:

Testing

The product is tested on multiple computers and monitors. It is imperative to evaluate, test and revise the product to make sure the quality and success of the product.

Mastering

Mastering can be as simple as writing a CD-ROM or floppy disk. Or it can be as complex as sending the files to a service that will create a pre-master from which the master is made.

Archiving and Duplication

The original files, including audio, video, and the native software formats, are archived for future upgrades or revisions. The duplicates are created from the original and packaged accordingly.

Marketing and Distribution

Marketing is significant to the success of a product. The survival of a company and its products depends greatly on the product reaching the maximum number of audience. Then comes the final step in the process which is distribution of the multimedia project.

4.0 Self-Assessment Exercise(s)

Identify four vital characteristics of multimedia systems.

_____
_____
_____
_____

5.0   Conclusion

From our studies in this unit, it is important to remember that there are four vital characteristics of multimedia systems. It is equally pertinent to note the core components of multimedia systems as well as the challenges for multimedia systems.

6.0   Summary

In this unit, we looked at the fundamental characteristics, components of multimedia systems and stages of multimedia production. We equally considered the challenges for multimedia systems. We hope you found the unit enlightening. To assess your comprehension, attempt the questions below.

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UNIT 3   MULITIMEDIA AUTHORINGSYSTEMS

CONTENTS

1.0   Introduction

The initial task we have in this unit is to explain the concept of multimedia authoring system and authoring paradigm. You might be tempted to think you're never going to get to grips with these terms. But do not worry - after a few lessons, things will start to feel familiar.

2.0   Intended Learning Outcomes (ILOs)

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

- describe the concept of an authoring system
- examine the significance of an authoringsystem
- explain the term 'authoringparadigm'
- list the main authoringparadigms
- mention the authoring paradigm best suited for rapidprototyping
- discuss the correlation between iconic/flow control andframe authoringparadigm.

3.0   MainContent

3.1   Authoring System

An Authoring System simply refers to a program which has pre-programmed elements for the development of interactive multimedia software titles. Authoring systems vary widely in orientation, capabilities, and learning curve. There is no such thing (at this time) as a

completely point-and-click automated authoring system; some knowledge of heuristic thinking and algorithm design isnecessary.

Whether you realise it or not, authoring is actually just a speeded-up form of programming; you do not need to know the intricacies of a programming language, or worse, an API, but you do need to understand how programs work.

3.2   Significance of an AuthoringSystem

It generally takes about 1/8th the time to develop an interactive multimedia project, such as a CBT (Computer Based Training) program, in an authoring system as opposed to programming it in compiled code. This means 1/8 the cost of programmer time and likely increased re-use of code (assuming that you pass this project's code to the next CBT project, and they use a similar or identical authoring system).

However, the content creation (graphics, text, video, audio, animation, etc.) is not generally affected by the choice of an authoring system; any production time gains here result from accelerated prototyping, not from the choice of an authoring system over a compiled language.

3.3   Multimedia Authoring Paradigms

The *authoring paradigm is a term used to describe* the methodology by which the authoring system accomplishes its task.

There are various paradigms, including:

3.3.1 Scripting Language

The Scripting paradigm is the authoring method closest in form to traditional programming. The paradigm is that of a programming language, which specifies (by filename) multimedia elements, sequencing, hotspots, synchronisation, etc. A powerful, object-oriented scripting language is usually the centerpiece of such a system; in-program editing of elements (still graphics, video, audio, etc.) tends to be minimal or non-existent. Scripting languages do vary; check out how much the language is object-based or object-oriented. The scripting paradigm tends to be longer in development time (it takes longer to code an individual interaction), but generally more powerful interactivity is possible. Since most Scripting languages are interpreted, instead of compiled, the runtime speed gains over other authoring methods are minimal. The media handling can vary widely; check out your system with your contributing package formats carefully. The Apple's HyperTalk for HyperCard, Assymetrix's OpenScript for ToolBookand

Lingo scripting language of Macromedia Director are examples of a Multimedia scripting language.

Here is an example lingo script to jump to a frame

global gNavSprite

on exitFrame
go the frame
play sprite gNavSprite
end

3.3.2 Iconic/FlowControl

This tends to be the speediest (in development time) authoring style; it is best suited for rapid prototyping and short-development time projects. Many of these tools are also optimised for developing Computer-Based Training (CBT). The core of the paradigm is the Icon Palette, containing the possible functions/interactions of a program, and the Flow Line, which shows the actual links between the icons. These programs tend to be the slowest runtimes, because each interaction carries with it all of its possible permutations; the higher end packages, such as Authorware (Figure 2.1)or IconAuthor, are extremely powerful and suffer least from runtime speed problems.
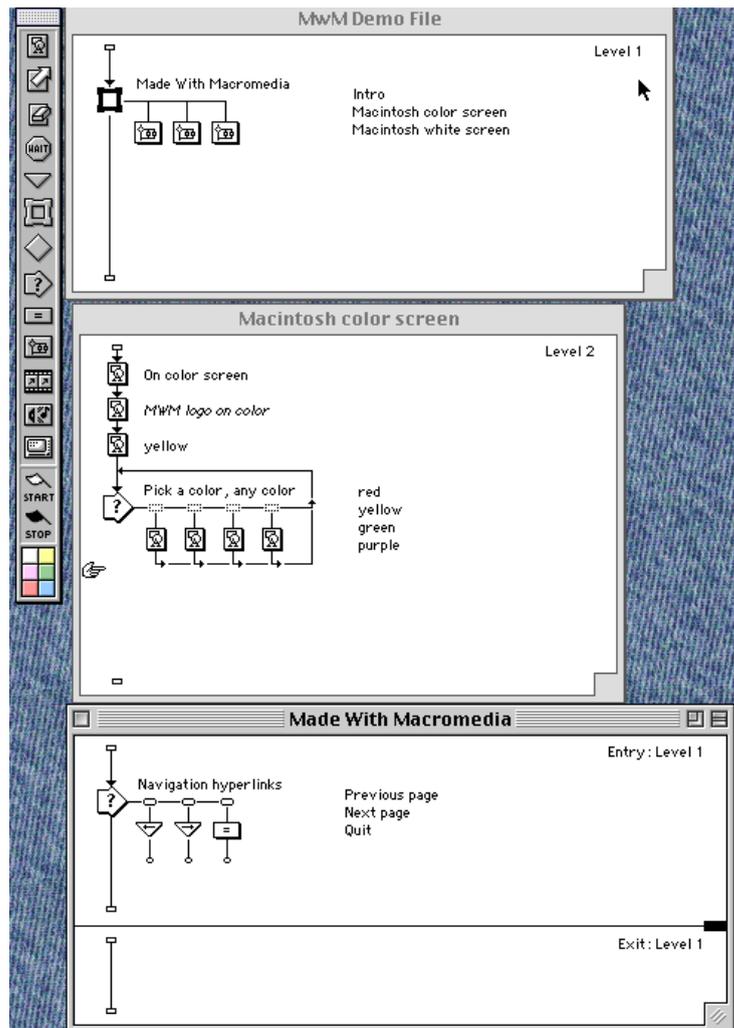
Fig. 2,.1: *Macromedia Authorware Iconic/Flow Control Examples*

3.3.3 Frame

-- The Frame paradigm is similar to the Iconic/Flow Control paradigm in that it usually incorporates an icon palette; however, the links drawn between icons are conceptual and do not always represent the actual flow of the program. This is a very fast development system, but requires a good auto-debugging function, as it is visually un-debuggable. The best of these have bundled compiled-language scripting, such as Quest (whose scripting language is C) or Apple MediaKit.

3.3.4 Card/Scripting

The Card/Scripting paradigm provides a great deal of power (via the incorporated scripting language) but suffers from the index-card structure. It is excellently suited for Hypertext applications, and supremely suited for navigation intensive (a la Cyan's "MYST" game) applications. Such programs are easily extensible via XCMDs and

DLLs; they are widely used for shareware applications. The best applications allow all objects (including individual graphic elements) to be scripted; many entertainment applications are prototyped in a card/scripting system prior to compiled-language coding.

3.3.5 Cast/Score/Scripting

The Cast/Score/Scripting paradigm uses a music score as its primary authoring metaphor; the synchronous elements are shown in various horizontal *tracks* with simultaneity shown via the vertical columns. The true power of this metaphor lies in the ability to script the behaviour of each of the cast members. The most popular member of this paradigm is Director, which is used in the creation of many commercial applications. These programs are best suited for animation-intensive or synchronised media applications; they are easily extensible to handle other functions (such as hypertext) via XOBJs, XCMDs, and DLLs.

4.0 Self-Assessment Exercise(s)

What is the significance of an authoring system?

_____

_____

5.0   Conclusion

In sum, an Authoring System refers to a program which has pre-programmed elements for the development of interactive multimedia software titles. It generally takes about 1/8th the time to develop an interactive multimedia project, in an authoring system as opposed to programming it in compiled codes. The term *authoring paradigm describes* the methodology by which the authoring system accomplishes its task.

6.0   Summary

In this unit, we considered authoring systems and authoring paradigms. We equally looked at the specific applications of the different authoring paradigms. Hoping that you understood the topics discussed, you may now attempt the questions below.

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MODULE 2   MULTIMEDIA SYSTEMS TECHNOLOGY

Unit 1   Media andSignals
Unit 2   Media Sources and Storage Requirements
Unit 3   Output Devices and StorageMedia

UNIT 1   MEDIA ANDSIGNALS

CONTENTS

1.0   Introduction

Media and signals are at the heart of every multimedia system. In this unit, we will discuss the concept of synchronisation and highlight typical examples of discrete and continuousmedia.

2.0   Intended Learning Outcomes (ILOs)

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

- distinguish between discrete and continuousmedia
- explain the concept ofsynchronisation
- identify analog and digitalsignals.

3.0   MainContent

3.1   Media andSignals

In this unit, we shall treat the concepts of media and signals distinctly to facilitate a deeper understanding.

What is media?

Media are communication outlets or tools used to store and disseminate information to the masses. It could also be referred to as components of mass media communications such as advertising, news media, publishing and so no.

3.1.1 Classifications of media

Multimedia, represents a variety of media and they are classified in accordance to different criteria as follows:

- Perception: In a typical multimedia environment, the information presented to people   should be such that cuts across the five senses such as hearing, seeing, smell, touch and taste (see figure 1). Although, current multimedia systems only employ the audio and visual senses. This is because, the technology required to involve the three order senses is not yet in place. Hence, in the current multimedia framework, text, image and video have been grouped as visual media while music and speech are under auditory media.
- Representation: the media information is being represented in various computer formats as ASCII code is used to represent text characters, PCM samples are used for audio signals representation, either of MPEG or PCM could be used for images while also MPEG or PCM format is used in the representation of video data.
- Presentation: in media presentation, we refers to the needed tools and devices used to input and output data accordingly. Examples are keyboard, mouse, microphone, camera, all are input devices while output devices include but not limited to speakers, screen, paper and so on.
- Storage: this refers to devices that aids storing of information or data and they include the following: paper, floppy disk, hard disk, microfilm, CD, DVD and so on.
- Transmission: this includes various information carriers that enables continuous transmission of data. This includes all transmission medium such as optical fiber, air, microwave, coaxial cable and so on.
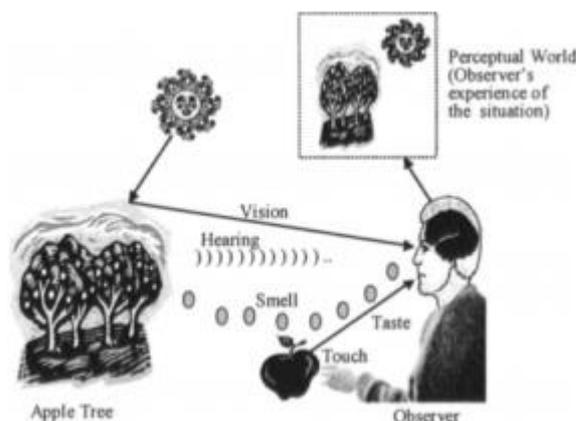

Fig   1: Sensory Perception

- **Discrete/ContinuousMedia:** Multimedia systems deal with the generation, manipulation, storage, presentation, and communication of information in digital form. This implies that the data may be in a variety of formats: *text, graphics, images, audio, and video*.

  A good number of this data is large and the different media may need *synchronisation*, i.e. the data may have temporal relationships as an integral property while some media are independent or static. Hence media can be divided into two types namely:**discrete** and **continuous**. The time-independent media such as normal data, text, single images are examples of discrete media while Video, animation and audio are examples of *continuous* media.

3.1.2 Analog and DigitalSignals

The world we sense is full of analog signals. Electrical sensors such as transducers, thermocouples, microphones etc convert the medium they sense into electrical signals. These signals are time-varying signals which conveys information. In electrical, the time varying signal is used to represent voltage level (see figure 2) and thus, analog signals are continuous in nature. Examples of analog signals are video and audio transmissions which are often transferred or recorded using analog signals.
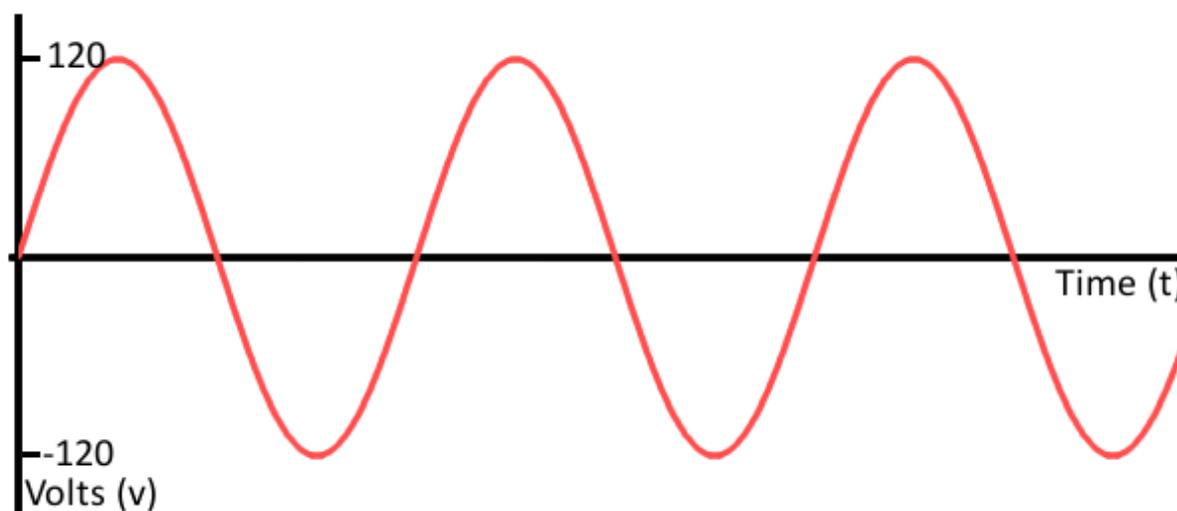
These analog signals must be converted to digital signals that computer can readily deal with using a special hardware devices called *Analog-to-Digital* converters.

Digital signals are discrete in nature that is, they must have a finite set of possible values.The signal operates in 0's and 1's where in digital devices (e.g computers), 0 means OFF (0V) while 1 means ON (5V). hence computers operates in two states for its voltage levels representation (see figure 3). It is important to note that not all audio and video signals are analog. Standardized signals such as HDMI for video and audio and MIDI, I^{2}S and so on are digitally transmitted.
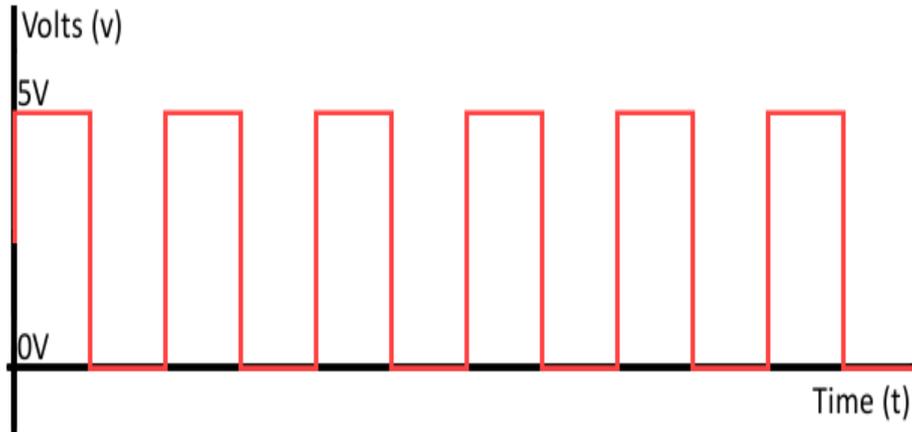
Digital-to-Analog converter is used to convert signals back from digital to analog.Note that Text, Graphics and some images are generated directly by computer and *do not* require digitising: they are generated directly in binary format.Handwritten text would have to be digitised either by electronic pen sensing of scanning of paper based form.

4.0 Self-Assessment Exercise(s)

List at least three common types of static media

_____

_____

5.0 Conclusion

We discovered that data may be in a variety of formats: ***text, graphics, images, audio, and video***. We equally saw typical examples of static and discretesignals.

6.0   Summary

In this unit, we learnt about discrete and continuous media. We equally described the term 'synchronisation' and examined analog and digital signals. Be assured that the facts gathered from this unit will be valuable for exploring multimedia applications. OK! Let us attempt the questions below.

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UNIT 2   MEDIA   SOURCES   AND   STORAGE   REQUIREMENTS

CONTENTS

1.0   Introduction

In this unit we will consider each media and summarise how it may be input into a multimedia system. The unit will equally analyse the basic storage requirements for each type of data.

2.0   Intended Learning Outcomes (ILOs)

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

- state two common sources of text and staticdata
- describe the terms graphics andimages
- describe the common procedure for capturing audiosignals
- explain the concept of a rawvideo.

3.0   MainContent

3.1   Texts and StaticData

The sources of this media are the keyboard, floppies, disks and tapes. Text files are usually stored and input character by character. Files may contain raw text or formatted text e.g HTML, Rich Text Format (RTF) or a program language source (C, Pascal,etc.)

The basic storage of text is 1 byte per character (text or format character). For other forms of data e.g. Spreadsheet files some formats

may store format as text (with formatting) others may use binary encoding.

3.2   Graphics

Graphics are usually constructed by the composition of primitive objects such as lines, polygons, circles, curves and arcs. Graphics are usually generated by a graphics editor program (*e.g.* Freehand) or automatically by a program (*e.g.* Postscript usually generated this way). Graphics are usually editable or revisable (unlike Images).

Graphics input devices include: keyboard (for text and cursor control), mouse, trackball or graphics tablet.

Graphics files may adhere to a graphics standard (OpenGL, PHIGS, GKS) Text may need to stored also. Graphics files usually store theprimitive assembly and do not take up a very high overhead.

3.3   Images

Essentially, images are still pictures which (uncompressed) are represented as a bitmap (a grid of pixels). They may be generated by programs similar to graphics or animation programs. But images may be scanned for photographs or pictures using a digital scanner or from a digital camera. Some Video cameras allow for still image capture also. Analog sources will require digitising. Digital images in form of photographs, line art or slides could be digitized as digitize images, where applications such as Adobe Photoshop could be used to perform editing and other formatting as may be required.
In using image-editing software, text and images could be combined by multimedia developers in order to create any work of art one could imagine.

Image data types

Representation of images could be done using techniques known as data type. Data type could be in the likes of monochrome and colored images where monochrome images is created using single color whereas colored image is created using multiple colors. The commonly used data types of images are as follows:

- **1-bit images**: Image is represented in pixels. A pixel is a picture elements in a digital image. 1 bit image can only store each pixel as a single bit of either 0 or 1. A bit has only two states represented in either on or off, white or black, true or false and so on. When such form of images exist, it is referred to as 1-bit

monochrome images, this is because it contains one color that is black or white for off and on state respectively. One of the challenges of 1-bit image is that the clarity or quality is very low.

A 1-bit image with resolution 640*480 needs a storage space of 640*480 bits.

640 x 480 bits. = (640 x 480) / 8 bytes = (640 x 480) / (8 x 1024) KB= 37.5KB.

- **8-bit Gray level images**: Every pixel of an 8-bit Gray level image is represented by a single byte (8-bits). This means that for each pixel of such image representation, can hold up to 2^8 = 256 values ranging from 0 – 255. Hence, the brightness of each pixel is measured in a scale of black (where 0 represents no brightness or intensity) to white (with 255 being of full brightness or intensity). For instance, one could have a dark pixel which could be represented with a value of 15 and a bright one of a value of 240.

A grayscale digital image is usually of a single sample for each pixel carrying intensity information. Images are made up of Gray shades varying from black being the weakest intensity to white being the strongest intensity. Grayscale images are also in the class of monochrome, thus are called monochromic showing the presence of one (mono) colour (chrome).
An image in Grayscale represents a bitmap where, a bitmap is a simple matrix of tiny dots (pixels) forming an image and display accordingly on a computer screen.

A 8-bit image with resolution 640 x 480 needs a storage space of 640 x 480 bytes=(640 x 480)/1024 KB= 300KB. Therefore an 8-bit image needs 8 times more storage space than 1-bit image.

- **24-bit colour images**: This has each pixel represented with 3 bytes usually RGB (Red, Green and Blue). A true colour is known with 256 shades of RGB for a total of 16777216 colour variations. This gives the opportunity of representing RGB colours in a large number of variations of images ranging to high quality photo graphic images or complex graphics.

Many of the 24-bit colour images are stored as 32-bit images with an extra byte for each pixel created to illustrate a special effect information and is known as an Alpha value.

A 24-bit color image with resolution 640 x 480 needs a storage space of 640 x 480 x 3 bytes = (640 x 480 x 3) / 1024=900KB without any compression.

Also 32-bit color image with resolution 640 x 480 needs a storage space of 640 x 480 x 4 bytes= 1200KB without any compression.

Disadvantages of a 24-bit color image

- It requires large storage space

- Many monitors can display only 256 different colours at any one time. Thus, it is wasteful to store more than 256 different colours in an image.

- **8-bit colour images**: in this data type, 8 bit or 1 byte represents a pixel and it is the method of storing an image information in a computer memory where the maximum number of colour that could be displayed at once is 256.

  It consist of two parts namely: colour map describing what colours are present in the image and the array of index value for each pixel in the image. Most times, colours are selected from a palette of 16,777,216 colours (24bits: 8 red, 8 green and 8 blue)

  A 8-bit color image with resolution 640 x 480 needs a storage space of 640 x 480 bytes=(640 x 480) / 1024KB= 300KB without any compression.

  Image file formats

- **GIF- Graphics Interchange Formats**- This is the most popularly used on internet and this is as a result of its compact size. It supports 256 colours and is recommended for small icons used for simple diagram and navigational purposes. It is lossless only for images of 256 colours or less.

- **JPEG- Joint Photographic Experts Group**- developed by the Joint Photographic Experts Group. It is a bitmap image file and can store information as 24-bit colour. JPEG has become the most popularly used picture format in Web and digital cameras saved images are of JPEG format too. It uses a lossy compression technique and works well with photographs, artwork and similar material but not so well with lettering, simple cartoons and line drawings.

- **PNG- Portable Network Graphics**- PNG supports 8 bit, 24 bits, 32 bits and 48 bits data types. It is the only lossless format that web browsers supports. Its format could be found in PNG-24, PNG-8 where the PNG-8 is similar to the GIF format. It can support up to 48 bits of colour information.

- **TIFF- Tagged Image File Format**- The TIFF format was developed by the Aldus Corporation in the 1980 and was later supported by Microsoft. TIFF is supported by many editing applications and is majorly used in bitmapped file format. Currently, TIFT uses both lossless and lossy compression format and can store images raging from 1 bit image, grayscale image, 8 bit color image, 24 bit RGB image and so on.

- **BMP- Bitmap**- The bitmap file format (BMP) data types is one of those that are not suitable for internets and this is due to its uncompressed format. It can store many different type of image of 1 bit image, grayscale image, 8 bit color image, 24 bit RGB image and so on.

- **EPS- Encapsulated Postscript**- This is a vector based graphic format and is ppular for saving images. It offers the flexibility of being imported to nearly any kind of of application. Its challenge is that it demands for more storage as compared to other formats.

- **PDF- Portable Document Format**- PDF format is usually platform independent. It is a vector graphics with in-built pixel graphics including compression options. It gives the opportunity to print from any document to a PDF file in as much as there exist an Adobe Acrobat on the system.

- **EXIF- Exchange Image File**- Exif includes specification of file format for audio that accompanies digital images. It is an image format used by digital cameras.

- **WMF- Windows MetaFile**- WMF metafiles are small, flexible and can only display images properly using their proprietary softwares only. It is a vector file format for MS-Windows operating environment.

- **PICT**- PICT images are useful in Macintosh software development and should be avoided in desktop publishing.

- **Photoshop**- Photoshop file format is created by Adobe and it can be imported directly into most desktop publishing applications.

3.4   Audio

Audio signals are continuous analog signals. They are first captured by microphones and then digitised and stored -- usually compressed as CD. In order to digitised audio, some steps are put in place such as: sampling, quantization and encoding.

Sampling: Sampling is the process of mapping out a signal at a regular spaced pattern in time with each mapping constituting a sample. The sampling rate is the measure of the number of times the audio signal is taken per second. Hence, a higher sampling rate implies that more numberof signal mapping are taken during a given time interval. Sampling rate is exactly $2f_m$ and is also known as Nyquist rate or minimum sampling rate which is measure in Herz (Hz) and is given as:

$$\mathbf{f_s = 2f_m}$$

Also, the intervals between the various audio signal mappings, is referred to as sampling interval. The sampling interval is given as:

$$\mathbf{T_s = 1/2f_m} \quad \text{seconds and is known as Nyquist Interval}$$

Sampling rates most often used in multimedia are 44.1kHz (CD-quality), 22.05kHz and 11.025kHz. Thus, 1 Minute of Mono CD quality audio requires 60*44100*2 Bytes which is approximately 5 Mb.

Quantization: quantization is the process of representing the samples of the sampled audio signal using integers or numbers. The amount numbers used to represent the value of each sample is referred to as sample size or bit depth or resolution. Quantization gives way for analog signals to be transformed to digital signals where it enables the audio signals to be trace back at the receivers end using numbers. Commonly used sample sizes are in the form of 8bits or 16 bits and the larger the sample, the more accurate the recovery of the audio signal at the receivers end. Quantization also enables samples to be rounded off to the nearest integer (quantization process) and when the amplitude is greater than the available intervals, a process known as clipping takes place where the

top of the bottom of the audio signal is clipped off.

Encoding: this technique is used to convert the quantized audio signal to binary numbers (0's and 1's). The binary numbers are used to convey the information within the digital device making up the communication system. Hence, the output of the system are series of 0's and 1's where a 1 is taken as a pulse and a 0 represents no pulse (see figure 1).
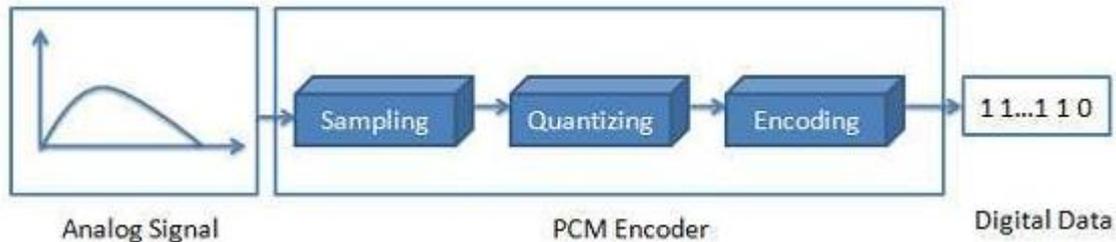
Fig 1: Analog audio signal to digital audio signal

3.5   Video

Analog Video is usually captured by a video camera and then digitised. There are a variety of video (analog and digital) formats.
Raw video can be regarded as being a series of single images. There are typically 25, 30 or 50 frames per second. Digital video clearly needs to be compressed.

4.0   Self-Assessment Exercise(s)

Describe the common procedure for capturing audiosignals

How are graphics constructed?

_____
_____
_____

5.0 Conclusion

We have been able to spot basic input and storage of text and static data. We discovered that, graphics are usually constructed by the composition of primitive objects such as lines, polygons, circles, curves and arcs. Images can be referred to as still pictures which (uncompressed) are represented as a bitmap. Audio signals are continuous analog signals. Raw video can be regarded as being a series of single images e.g explorer.

6.0   Summary

In summary, this unit looked at the basic input and storage of text and static data. We also considered how graphics, images, audio and video are represented. You can now attempt the questions below.

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UNIT 3   OUTPUT DEVICES AND STORAGEMEDIA

CONTENTS

1.0   Introduction

Now that you have been introduced to common types of media, we will now consider output devices and storage units for multimedia systems.

2.0   Intended Learning Outcomes (ILOs)

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

- list output devices for a basic multimediasystem
- describe the common modes ofstorage
- identify the key issues I/Operformance
- differentiate between DVD-Video andDVD-ROM
- itemise the key components of a RAIDSystem
- mention the storage parameters that affect how data isstored.

3.0   MainContent

3.1   OutputDevices

Usually, multimedia systems require output devices. The output devices for a basic multimedia system include:

- A High Resolution ColourMonitor
- CD Quality AudioOutput
- Colour Printer

- Video Output to save Multimedia presentations to (Analog) Video Tape, CD-ROMDVD.
- Audio Recorder (DAT, DVD, CD-ROM, (Analog)Cassette)
- Storage Medium (Hard Disk, Removable Drives,CD-ROM)

3.2   High PerformanceI/O

Before proceeding, let us consider some key issues that affect storage media:

- Large volume ofdata
- Real timedelivery
- Dataformat
- StorageMedium
- Retrievalmechanisms

First two factors are the real issues that storage media have to contend with. Due to the volume of data, compression might be required. The type of storage medium and underlying retrieval mechanism will affect how the media is stored and delivered. Ultimately any system will have to deliver high performance I/O. We will discuss this issue before going on to discuss actual Multimedia storage devices.

There are four factors that influence I/O performance:

Data

Data is high volume, maybe continuous and may require contiguous storage. It also refers to the direct relationship between size of data and how long it takes to handle. Compression and also distributed storage.

Data Storage

The strategy for data storage depends of the storage hardware and the nature of the data. The following storage parameters affect how data is stored:

- StorageCapacity
- Read and Write Operations ofhardware
- Unit of transfer of Read andWrite
- Physical organisation of storage units
- Read/Write heads, Cylinders per disk, Tracks per cylinder, Sectors per Track
- Readtime
- Seektime

Data Transfer

Depends on how data generated and written to disk, and in what sequence it needs to retrieved. Writing/Generation of Multimedia data is usually sequential *e.g.* streaming digital audio/video direct to disk. Individual data (*e.g.* audio/video file) usually streamed.
RAID architecture can be employed to accomplish high I/O rates by exploiting parallel disk access.

Operating System Support

Scheduling of processes when I/O is initiated. Time critical operations can adopt special procedures. Direct disk transfer operations free up CPU/Operating system space.

3.3   BasicStorage

Basic storage units have problems dealing with large multimedia data

- Single Hard Drives -- SCSI/IDE Drives. So called *AV* (Audio-Visual) drives, which avoid thermal recalibration between read/writes, are suitable for desktop multimedia. New drives are fast enough for direct to disk audio and video capture. But not adequate for commercial/professional Multimedia. Employed in RAID architectures.
- Removable Media -- Jaz/Zip Drives, CD-ROM, DVD. Conventional (dying out?) floppies not adequate due 1.4 Mb capacity. Other media usually ok for backup but usually suffer from worse performance than single harddrives.

3.4   Redundant Array of Inexpensive Disks(RAID)

The concept of **RAID** has been developed to fulfill the needs of current multimedia and other application programs which require fault tolerance to be built into the storage device.

Raid technology offers some significant advantages as a storage medium:

- Affordable alternative to massstorage
- High throughput andreliability

The cost per megabyte of a disk has been constantly dropping, with smaller drives playing a larger role in this improvement. Although larger disks can store more data, it is generally more power effective to use small diameter disks (as less power consumption is needed to spin the smaller disks). Also, as smaller drives have fewer cylinders, seek distances are correspondingly lower.

Following this general trend, a new candidate for mass storage has appeared on the market, based on the same technology as magnetic disks, but with a new organisation. These are arrays of small and inexpensivedisksplacedtogether,basedontheideathatdiskthroughput can be increased by having many disk drives with many heads operating in parallel. The distribution of data over multiple disks automatically forces access to several disks at one time improving throughput. Disk arrays are therefore obtained by placing small disks together to obtain the performance of more expensive high enddisks.

The key components of a RAID System are:

- set of disk drives, disk arrays, viewed by user as one or more logicaldrives
- data may be distributed acrossdrives
- redundancy added in order to allow for disk failure.

3.5   Optical Storage

Optical storage has been the most popular storage medium in the multimedia context due its compact size, high density recording, easy handling and low cost perMB.

CD is the most common and we discuss this below. Laser disc and recently DVD are alsopopular.

3.6   CDStorage

CDs (compact discs) are thin pieces of plastic that are coated with aluminum and used to store data for use in a variety of devices, including computers and CD players. The main or standard type of CD is called a CD-ROM; ROM means read-only memory. This type of CD is used to store music or data that is added by a manufacturer prior to sale. It can be played back or read by just about any CD player as well as most computers that have CD drives. A consumer cannot use this type of CD to record music or data files; it is not erasable orchangeable.

If consumers want to purchase recordable CDs to record music store data files, they usually have some options available to them. One is the CD-R, which is the typical choice for an individual who only wants to add data files or music to a CD once. An individual uses a CD burner, which is a component of many modern computer systems, to record to thesediscs.

Some recordable CDs are classified as CD+R. This type of disc allows consumers to record music or data to it, but provides nearly twice the amount of space that is available with a CD-R. A CD-RW also has a place among the recordable CDs. This one is a bit different, because it allows consumers to erase it and record over it again. Otherwise, it can be used in the same manner as CD-Rs and CD+Rs.

3.7   DVD

DVD, which stands for *Digital Video Disc*, *Digital Versatile Disc*, is the next generation of optical disc storage technology. This disc has become a major new medium for a whole host of multimedia system:

It is essentially a bigger, faster CD that can hold video as well as audio and computer data. DVD aims to encompass home entertainment, computers, and business information with a single digital format, eventually replacing audio CD, videotape, laserdisc, CD-ROM, and perhaps even video game cartridges. DVD has widespread support from all major electronics companies, all major computer hardware companies, and most major movie and music studios, which is unprecedented and says much for its chances of success (or, pessimistically, the likelihood of it being forced down our throats).

It is important to understand the difference between DVD-Video and DVD-ROM. DVD-Video (often simply called DVD) holds video programs and is played in a DVD player hooked up to a TV. DVD-ROM holds computer data and is read by a DVD-ROM drive hooked up to a computer. The difference is similar to that between Audio CD and CD-ROM. DVD-ROM also includes future variations that are recordable one time (DVD-R) or many times (DVD-RAM). Most people expect DVD-ROM to be initially much more successful than DVD-Video. Most new computers with DVD-ROM drives will also be able to play DVD-Videos.

There is also a DVD-Audio format. The technical specifications for DVD-Audio are not yet determined.

4.0 Self-Assessment Exercise(s)

What are the storage parameters that affect how data is stored?

_____

_____

_____

5.0 Conclusion

To wrap up, recall that the type of storage medium and underlying retrieval mechanism will affect how the media is stored and delivered. RAID architecture can be employed to accomplish high I/O rates. Basic storage units have problems dealing with large multimedia data. CDs (compact discs) are thin pieces of plastic that are coated with aluminum and used to store data for use in a variety of devices. DVDs are essentially optical storage discs that can hold video as well as audio and computer data. Typically, they are bigger and faster than CDs.

6.0 Summary

This unit provided an overview of output devices for a basic multimedia system. We also highlighted the common modes of storage, key issues affecting storage media as well as factors that affect I/O performance. However, to assess your level of assimilation, you would need to attempt the questionsbelow.

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MODULE3   MULTIMEDIA DATA REPRESENTATIONS

UNIT 1   BASICS OF DIGITALAUDIO

CONTENTS

1.0   Introduction

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

2.0   Intended Learning Outcomes (ILOs)

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

- explain the theory ofdigitisation
- define the term 'samplingrate'
- list the typical audioformats
- describe the concept of colourrepresentation
- identify the key role of the Adaptive Delta Pulse Code Modulation.

3.0   MainContent

3.1   The Theory ofDigitisation

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 valuesof 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 *quantisation* of the domain of real numbers.

3.2   Digitisation ofSound

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

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

A variety of sound sources:

Source

Generates Sound

- Air Pressurechanges
- *Electrical* -- LoudSpeaker
- *Acoustic* -- Direct PressureVariations

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

Destination

Receives Sound

- *Electrical* -- Microphone produces electricsignal
- *Ears* -- Responds to pressure **hear**sound
- To input sound into a computer: it needs to sampled ordigitised;

- Microphones, video cameras produce *analog signals* (continuous-valued voltages) as illustrated in Fig1
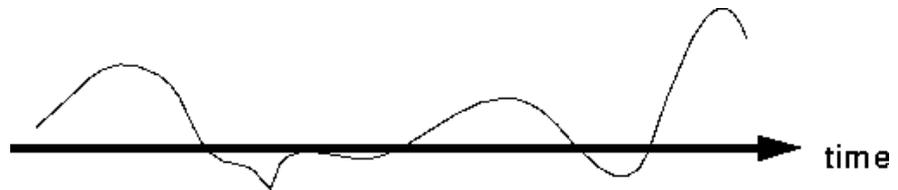

Fig. 1.1: Continuous Analog Waveform

- To get audio or video into a computer, we have to *digitise* it (convert it into a stream of numbers) **Need to convert Analog-to-Digital** -- Specialisedhardware
- 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).
- *Quantisation* - divide the vertical axis (signal strength) into pieces. Sometimes, a non-linear function isapplied.
  - o   8-bit quantisation divides the vertical axis into 256 levels. 16 bit gives you 65536 levels.

3.3   Typical AudioFormats

The typical audio formats are outlined below*:*

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

3.4   ColourRepresentations

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".

Table 1 .1: Colours

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

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 Self-Assessment Exercise(s)

Explain the term *'sampling rate'*

_____

_____

5.0 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 (***quantisation of the domain of real numbers***). Popular audio file formats include .au (Unix workstations), .aiff (MAC, SGI), .wav (PC, DECworkstations).

6.0 Summary

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

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UNIT 2   GRAPHICS/ IMAGE DATASTRUCTURE

CONTENTS

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 recognise and translate formats from othersystems.

2.0   Intended Learning Outcomes (ILOs)

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

- give a concise definition ofpixel
- discuss the factor that determines the quality of amonitors' image
- discover typical imagesamples
- identify how pixels are stored in differentimages.

3.0   MainContent

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   MonitorResolution

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.

3.3   Typical ImageSamples

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

3.3.1 Monochrome/ Bitmap Images

An example of a 1 bit monochrome image is illustrated in Figure 2.1 below where:

Fig.2.1: Monochrome Image

Sample Monochrome Bit-Map Image

- Each pixel is stored as a single bit (0 or1)
- A 640 x 480 monochrome image requires 37.5 KB of storage.
- Dithering is often used for displaying monochromeimages

3.3.2 Grey-ScaleImage

A common example of gray-scale image is illustrated in Figure 2.2 below:

Fig. 2.2: Example of a Gray-scale Bit-map Image

- Each pixel is usually stored as a byte (value between 0 to255)
- A 640 x 480 greyscale image requires over 300 KB ofstorage

3.3.3   8-bit Colour Images

An example of an 8-bit colour image is illustrated in Figure 2.3 below where:

Fig. 2.3: Example of 8-Bit Colour Image

- One byte for eachpixel
- Supports 256 out of the millions possible, acceptablecolour 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-bitgreyscale)

3.3.4   24-bit Colour Images

Base: 1
An example 24-bit colour image is illustrated in Figure 2.4 where:

Fig. 2.4: Example of 24-Bit Colour Image

- Each pixel is represented by three bytes (e.g.,RGB)
- Supports 256 x 256 x 256 possible combinedcolours (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 effectinformation

4.0 Self-Assessment Exercise(s)

What factor determines a monitors' resolution?

_____
_____
_____

5.0 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.

6.0 Summary

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

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UNIT 3   STANDARD SYSTEMFORMATS

CONTENTS

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   Intended Learning Outcomes (ILOs)

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

- identify popular system dependentformats
- state typical usage of the standard system independentformats.

3.0   MainContent

3.1   System DependentFormats

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

- Microsoft Windows:BMP
- Macintosh: PAINT andPICT
- X-windows: XBM

3.2   System IndependentFormats

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

- GIF (GIF87a,GIF89a)
- JPEG
- TIFF
- PNG
- Graphics AnimationFiles
- Postscript/EncapsulatedPostscript

3.2.1 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.

Advantages of GIF

- Graphic Interchange Format has 256 colors.
- It is perfect for logos.
- It is best for flat areas of color that come with a distinct region.
- It works with the lossless compression process.
- It is ideal for small animations.
- It is suitable for icons that come with small colors.

Disadvantages of GIF

- It demands for a bigger file size compared to the PNG format.
- It is the oldest among the image formats.

3.2.2 JPEG

- A standard for photographic image compression created bythe Joint Photographics ExpertsGroup
- Takes advantage of limitations in the human vision systemto achieve high rates ofcompression

- Lossy compression which allows user to set the desired levelof quality/compression.

Advantages of Joint Photographic Experts Group

- It uses 24bit color.
- The Joint Photographic Experts Group is great for high details and high-quality images.
- It converts with lossy compression.
- It was approved as the standard image format in 1994.
- Most often, the design and photography industry uses this kind of image format.
- It is the best image format if the person is willing to give up the quality for the sake of its size.

Disadvantages of Joint Photographic Experts Group

- The Joint Photographic Experts Group does not support transparency.
- It does not work well for logos and icons.

3.2.3 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 latersupported by theMicrosoft

3.2.4   Portable Network Graphic (PNG)

Port network graphic uses 24 bits colour and is most suitable for icons, flat areas and logos. It is more preferable than GIF because of its higher level of advance transparency channel over GIF. PNG generates big file size from its image and so is not very good for saving big images.

- TIFF is a lossless format (when not utilising the new JPEG tag which allows for JPEGcompression)
- It does not provide any major advantages over JPEG and is not user-controllable.
- It appears to be declining inpopularity

3.2.5 Graphic AnimationFiles

- FLC - main animation or moving picture file format,originally created by AnimationPro
- FLI - similar toFLC
- GL - better quality moving pictures, usually large filesizes

3.2.6 Postscript/EncapsulatedPostscript

- This is a typesetting language which includes text as well as vector/structured graphics and bit-mappedimages
- Used in several popular graphics programs (Illustrator, FreeHand)
- Does not provide compression, files are oftenlarge

4.0 Self-Assessment Exercise(s)

State one limitation and delimitation of GIF

_____
_____
_____

5.0 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/EncapsulatedPostscript.

6.0 Summary

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

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UNIT 4   COLOUR INMULTIMEDIA

CONTENTS

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   Intended Learning Outcomes (ILOs)

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

* give a concise definition ofcolour
* explain the concept of spectrum oflight
* appreciate the science ofcolours
* describe a visiblelight
* identify the similarity between the eye and acamera
* discover the benefits and challenges of usingcolour
* state the guidelines of usingcolour.

3.0   MainContent

3.1   Basics ofColour

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.

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. By defining a colour space, colours can be identified numerically by theircoordinates.

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

The science of colour is sometimes called ***chromatics***. It includes the perception of colour by the human eye and brain, the origin of colour in materials, colour 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 andSpectra

- 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 thefigure below.
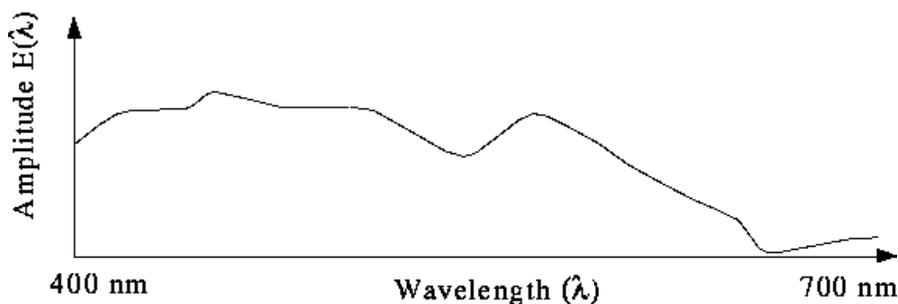
Fig.4.1: Light Wavelengths

3.1.2 The HumanRetina

- The eye is basically just like acamera
- Each neuron is either a *rod* or a *cone*. Rods are not sensitiveto 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.
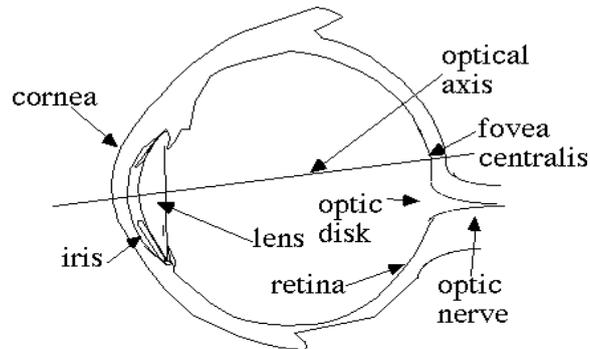

Fig. 4..2: Human Visual System

3.1.3 Cones andPerception

- Cones come in three 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 humaneye.
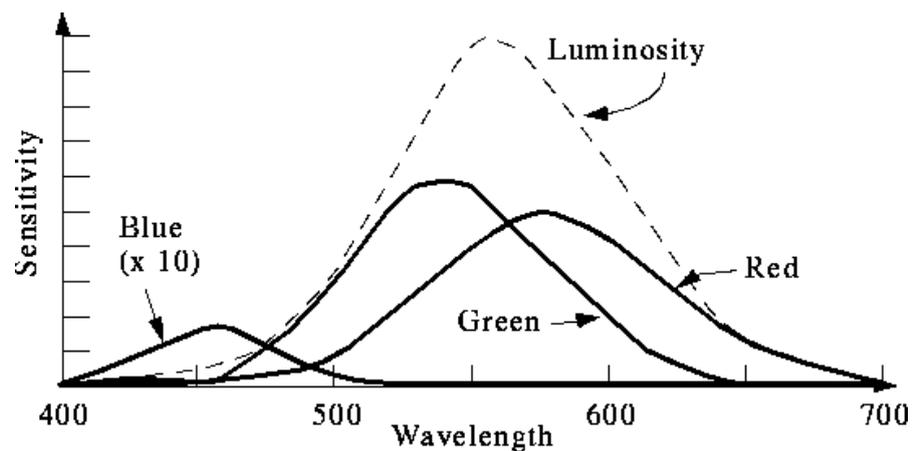

Fig. 4.3: Cones and Luminous-efficiency Function of the Human Eye

- 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 3numbers:

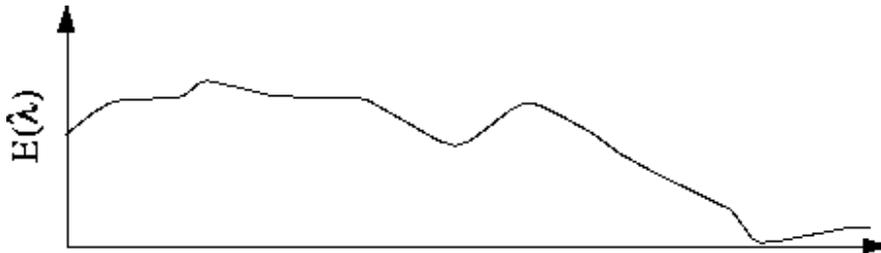$$R = \int E(\lambda)\, S_R(\lambda)\, d\lambda$$

Fig. 4.4: 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 three dimensional vectorspace.

3.2 Guidelines for ColourUsage

The main guidelines for colour are as follows:

1. Do not use too many colours. Shades of colour, greys, and pastel colours are often the best. Colour coding should be limited to no more than five to seven different colours although highly trained users can cope with up to 11shades.
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 categorise, differentiate and highlight, and not to give information, especially quantitativeinformation.

3.3   Benefits and Challenges of usingColour

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

However, colour is difficult to use correctly. The environment affects human colour perception e.g. lighting conditions may change thecolours 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 andgreen.

4.0 Self-Assessment Exercise(s)

Give an analogy between the human eye and a camera

_____
_____
_____

5.0 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.

6.0 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 theunit.

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MODULE 4   MULTIMEDIA COMPRESSION

Unit 1   Rudiments of Multimedia Compression
Unit 2   Source Coding Techniques
Unit 3   Video and Audio Compression
Unit 4   Image Histogram and Processing

UNIT 1   RUDIMENTS OF MULTIMEDIA COMPRESSION

CONTENTS

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        3.2   Categories of Multimedia Compression
                3.2.1 Lossy Compression
                3.2.2 Lossless Compression
        3.3   Lossy versus Lossless
        3.4   Mathematical and Wavelet Transformation
                3.4.1 JPEG Encoding
                3.4.2 H.261, H.263, H.264
4.0   Self-Assessment Exercise(s)
5.0   Conclusion
6.0   Summary
7.0   Further Readings

1.0   Introduction

Essentially, video and audio files are very large. Unless we develop and maintain very high bandwidth networks (Gigabytes per second or more) we have to compress these files. However, relying on higher bandwidths is not a good option.

Thus, compression has become part of the representation or *coding* scheme. In this unit, we will learn about basic compression algorithms and then go on to study some actual coding formats.

2.0   Intended Learning Outcomes (ILOs)

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

•   explain transform coding
•   describe the notion of lossless compression

- identify typical applications of lossy and losslesscompression
- discuss how images are represented in the different forms of encoding
- outline the basic lossy compressionschemes.

3.0 MainContent

3.1 Overview of MultimediaCompression

Multimedia compression is a broad term that refers to the compression of any type of multimedia (i.e. combination of media and content forms), most notably graphics, audio, andvideo.

Multimedia actually derives from data sampled by a device such as a camera or a microphone. Such data contains large amounts of random noise, thus, traditional lossless compression algorithms tend to do a poor job compressing multimedia. Multimedia compression algorithms, traditionally known as *codecs*, work in a lossy fashion, the entire process is known as transform coding.

The term **Transform coding** is a technique for compressing signals such as audio signals (1-D) or images (2-D). In transform coding, a frequency transform or other basic transformation is applied before entropy coding. The inverse transformation is applied after decoding. This has a considerable benefit since it produces coefficients that have a statistically significant distribution which can be modeled and compressed moreeasily.

This implies that, after transformation, some coefficients are predictably greater, others smaller. Thus, some coefficients can be neglected or quantized (lossy compression) and/or entropy encoded (lossless compression). We shall see these categories of compression in the ensuing unit.

Categories of MultimediaCompression

Multimedia compression can be broadly classified as Lossless and Lossy compression.

3.1.1 Lossy Compression

In information technology, "*lossy*" compression is a data encoding method which discards some of the data, in order to achieve its goal, with the result that decompressing the data yields content that is different from the original, though similar enough to be useful in some way.

Lossy compression is most commonly used to compress multimedia data (audio, video, still images), especially in applications such as streaming media and internet telephony. Lossy compression formats suffer from generation loss: repeatedly compressing and decompressing the file will cause it to progressively lose quality. Information-theoretical foundations for lossy data compression are provided by rate-distortion theory.

Types of Lossy Compression Schemes

There are two basic lossy compression schemes:

- In *lossy transform codecs*, samples of picture or sound are taken, chopped into small segments, transformed into a new basis space, and quantized. The resulting quantised values are then entropy coded.
- In *lossy predictive codecs*, previous and/or subsequent decoded data is used to predict the current sound sample or image frame. The error between the predicted data and the real data, together with any extra information needed to reproduce the prediction, is then quantised andcoded.

In some systems, the two techniques are combined, with transform codecs being used to compress the error signals generated by the predictive stage.

3.1.2 LosslessCompression

Lossless compression is a compression technique that does not lose any data in the compression process. This compression "packs data" into a smaller file size by using a kind of internal shorthand to signify redundant data. If an original file is 1.5MB, lossless compression can reduce it to about half that size, depending on the type of file being compressed. This makes lossless compression convenient for transferring files across the Internet, as smaller files transfer faster. Lossless compression is also handy for storing files as they take up less room.

The zip convention, used in programs like WinZip, uses lossless compression. For this reason zip software is popular for compressing program and data files. That is because when these files are decompressed, all bytes must be present to ensure their integrity. If bytes are missing from a program, it will not run. If bytes are missing from a data file, it will be incomplete and garbled. GIF image files also use lossless compression.

Lossless compression has advantages and disadvantages. The advantage is that the compressed file will decompress to an exact duplicate of the original file, mirroring its quality. The disadvantage is that the compression ratio is not all that high, precisely because no data is lost.

Typical Lossless Compression File Formats

Audio

- Waveform audio format(WAV)
- Free Lossless Audio Codec(FLAC)
- Apple Lossless Audio Codec(ALAC)
- ATRAC AdvancedLossless
- Audio LosslessCoding
- MPEG-4 SLS
- Direct Stream Transfer(DST)
- DTS-HD MasterAudio
- Meridian Lossless Packing(MLP)
- Monkey's AudioAPE
- RealPlayer – RealAudioLossless
- Shorten – SHN,TTA – True AudioLossless
- WMALossless

Graphics

- Adaptive Binary Optimisation(ABO)
- JPEG XR
- Progressive Graphics File(PGF)
- Portable Network Graphics(PNG)
- Tagged Image File Format(TIFF)

Video

- Animation codec
- CorePNG,Dirac
- FFV1
- JPEG 2000
- Huffyuv

- Lagarith
- MSU Lossless VideoCodec
- SheerVideo

3.2   Lossy versusLossless

Lossless and lossy compressions have become part of our every day vocabulary largely due to the popularity of MP3 music files. A standard sound file in WAV format, converted to an MP3 file will lose much data as MP3 employs a lossy, high-compression algorithm that tosses much of the data out. This makes the resulting file much smaller so that several dozen MP3 files can fit, for example, on a single compact disk, verses a handful of WAV files. However the sound quality of the MP3 file will be slightly lower than the originalWAV.

The advantage of lossy methods over lossless methods is that in some cases a lossy method can produce a much smaller compressed file than any lossless method, while still meeting the requirements of the application.

Lossy methods are most often used for compressing sound, images or videos. This is because these types of data are intended for human interpretation where the mind can easily "fill in the blanks" or see past very minor errors or inconsistencies – ideally lossy compression is transparent (imperceptible), which can be verified via an ABX test.

3.3   Mathematical and WaveletTransformation

Mathematical and wavelet transformation is the process through which images are converted to mathematical functions. Discreet Cosine Transformation uses series of cosine functions to approximate image. This technique is used with JPEG, MPEG1 and MPEG 2 formats. A wavelet function is used to approximate the image. This can be used with the JPEG 2000 and MPEG 4formats.

3.3.1 JPEG Encoding

In this encoding, an image is represented by a two dimensional array of pixels. A Grayscale picture of 307*200 pixels is represented by 2,457,600 bits and a color picture is represented by 7,372,800 bits. Dueto the number of calculations to be had in a JPEG format of a grayscale picture, it is divided into blocks of 8*8 pixels. The number of the units' id equal to the number of mathematical equations of each picture. The whole idea of JPEG is to change the picture into a linear set of numbers that reveals the redundancies. In addition to those techniques, MPEG is also a Lossy Compression technique. It is a way to

encode the moving

images and audio included in it. It supports many video formats from mobile phone to HD TV.

3.4.2 H.261, H.263, H.264

H.261 is designed for video telephony and video conferencing applications. It was developed in 1988-1990. Data rate is a multiplication of a 64 kb/s. H.263 is a video coding technique for low bit rate communication. In addition, a 30% of bit saving can be done by this technique when it is compared to the MPEG-1. H.264 is a joint project of ITU-Ts Video Experts Group and the ISO/IEC MPEG group. All those three methods use different methods of reducing redundant data. There for the output differs from bit rate, quality and latency.

5.0   Conclusion

In this unit, we learnt that **Transform coding** is a technique for compressing signals such as audio signals (1-D) or images (2-D). Multimedia compression can be broadly classified as Lossless and Lossy compression. Discreet Cosine Transformation uses series of cosine functions to approximate image. This technique is used with JPEG, MPEG1 and MPEG2 formats. A wavelet function is used to approximate the image. We equally discovered that wavelet transform techniques will be a good implementation technique for the next generation.

6.0   Summary

In this unit, we considered multimedia compression and the categories of multimedia compression (lossy and lossless). We equally learnt about the specific applications of these categories of multimedia. You may now proceed to the tutor marked assignmentbelow.

7.0   FurtherReadings

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UNIT 2   SOURCE CODINGTECHNIQUES

CONTENTS

1.0   Introduction

In this unit, you will learn about *fourier transform*. You would also learn about the common types of transforms and how signals are transformed from one domain to another. Do take note of these key points.

2.0   Intended Learning Outcomes (ILOs)

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

- explain the concept of the Discreet FourierTransform
- identify the common types oftransforms
- describe how signals are transformed from one domain tothe other
- mention the different classes ofsignals
- discuss the common applications of Fourier transforms in multimediaprocessing.

3.0   MainContent

3.1   Discrete FourierTransform

The Discrete Fourier Transform (DFT) is a specific form of Fourier analysis for converting one function (often in the time or spatial domain) into another (frequency domain). DFT is widely employed in signal processing and related fields to analyse frequencies contained in a sample signal, to solve partial differential equations, and to perform

other operations such as convolutions. Fast Fourier Transform (FFT) isan efficient implementation of DFT and is used, apart from other fields, in digital image processing. Fast Fourier Transform is applied to convert an image from the image (spatial) domain to the frequency domain. Applying filters to images in frequency domain is computationally faster than to do the same in the image domain.

Mathematically, Suppose
$f = [f_0, f_1, f_2, ..., f_{N-1}]$

is a sequence of length N. Then the *discrete Fourier transform* can be defined as:
$f=[F_0, F_1, F_2, ..., F_{N-1}]$ 3.1

Where   3.2

$$F_u = \sum_{x=0}^{N-1} f(x)exp[-2\pi i \frac{xu}{M}]f_u$$

The formula for the inverse DFT is very similar to the forward transform:

$$x_u = \sum_{x=0}^{N-1} f(x)exp[2\pi i \frac{xu}{M}]f_u \quad 3.3$$

When you try to compare equations 3.2 and 3.3., you will notice that there are really only two differences:

1   there is no scaling factor1/N in the Discrete Fourier Transform of (3.3)
2   the sign inside the exponential function is now negative in DFT instead of positive.

3.2   The Fast FourierTransform

One of the many aspects which make the DFT so attractive for image processing is the existence of very fast algorithm to compute it. There are a number of extremely fast and efficient algorithms for computing a DFT; any of such algorithms is called a fast Fourier transform, or FFT. When an FFT is used, it reduces vastly the time needed to compute a DFT.

A particular FFT approach works recursively by separating the original vector into two halves as represented in equation 3.4 and 3.5, computing the FFT of each half, and then putting the result together. This means that the FFT is most different when the vector length is a power of 2.

$$F(u) = \sum_{k=0}^{M-1} f(x) exp\left[-2\pi i^{\frac{xu}{M}}\right] 3.4$$

$$f(n) = \sum_{k=0}^{M-1} F(u) exp\left[2\pi^{\frac{xu}{M}}\right] 3.4$$

Table 3.1 is used to depict the benefits of using the FFT algorithm as opposed to the direct arithmetic definition of equation 3.4 and 3.5 by comparing the number of multiplication required for each method. For a vector of length 2^n, the direct method takes $(2^n)^2 = 2^{2n}$ multiplications; while the FFT takes only $n2^n$. Here the saving with respect to time is of an order of $2^n/n$. Obviously, it becomes more attractive to use FFT algorithm as the size of the vector increases.

Because of this computational advantage, it is advisable for any implementation of the DFT to use an FFT algorithm.

Table 2.1: Comparison of FFT and direct arithmetic

2^{n}	Direct Arithmetic	FFT	Increase in speed
4	16	8	2.0
8	84	24	2.67
16	256	64	4.0
32	1024	160	6.4
64	4096	384	10.67
128	16384	896	18.3
256	65536	2048	32.0
512	262144	2406	56.9
1024	1048576	10240	102.4

3.3   Two-dimensional Discrete Fourier Transform(DFT)

In two dimensions, the DFT takes a matrix as input, and returns another matrix, of the same size as output. If the original matrix values are $f(x,y)$, where x and y are the indices, then the output matrix values are $F(u,v)$. We call the matrix F the Fourier transform f and write

$$F = \mathcal{F}(f).$$

Then the original matrix *f* is the inverse Fourier transform of F, and we write

$$f = \mathcal{F}^{-1}(F)$$

We have seen that a (one-dimensional) function can be written as a sum of sines and cosines. Given that an image may be considered as a two dimensional function, it seems reasonable to assume that F can be expressed as sums of "corrugations" functions which have the general form
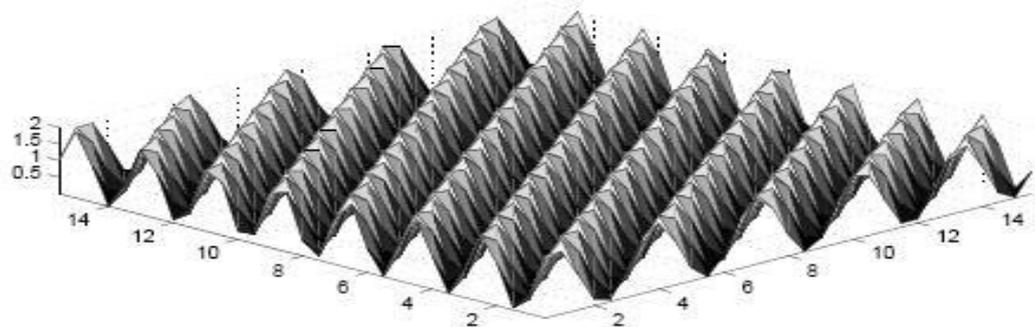
$$z = a \sin(bx + cy)$$

Fig.2.1: CorrugateFunction

A sample of such function is depicted in Figure 2.1. And this is in fact exactly what the two dimensional Fourier transforms does: it rewrites the original matrix in terms of sums ofcorrugation.

The definition of the two-dimensional discrete Fourier transform is very similar to that for one dimension. The forward and inverse transforms for an *M x N* matrix where for notational convenience we assume that the x indices are from 0 to *M-1* and the *y* indices are from 0 to *N-1* are:

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \exp\left[-2\pi i\left(\frac{xu}{M}+\frac{yv}{N}\right)\right]$$

3.6

$$F(x,y) = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} F(u,v) \exp\left[-2\pi i\left(\frac{xu}{M}+\frac{yv}{N}\right)\right]$$

3.7

You may need to revise your mathematics to fully comprehend the formulas. However, they are not as difficult as they look.

3.4   Properties of Two-Dimensional FourierTransform

All the properties of the one-dimensional DFT transfer into two dimensions. We shall briefly consider some which are of particular use for image processing.

Similarity- A close study of the formulae for the forward and inverse transforms reveals some similarity except for the scale factor *1/M N* in the inverse transform and the negative sign in the exponent of the forward transform. This means that the same algorithm, only very slightly adjusted, can be used for both the forward and inverse transform. The DFT can thus be used as a spatialFilter

Linearity - An important property of the DFT is its linearity; the DFT of a sum is equal to the sum of the individual DFT's, and the same goes for scalar multiplication:

Thus
$$\mathcal{F}(f+g) = \mathcal{F}(f) + \mathcal{F}(g)$$

$$\mathcal{F}(kf) = k\,\mathcal{F}(f)$$
Where $k \,||$ is a scalar product and *f* and *g* are matrices. This follows directly from the definition given in equation 3.6

This property is of great use in dealing with image degradation such as noise which can be modeled as a sum: $d = f + n$

where *f* is the original image, *n* is the noise, and *d* is the degraded image. Since

$$\mathcal{F}(d) = \mathcal{F}(f) + \mathcal{F}(n)$$
We may be able to remove or reduce *n* by modifying the transform. And we shall see some noise appear on the DFT in a way which makes it particularly easy to remove

3.5   The Discrete-time Fourier Transform(DTFT)

The **Discrete-time Fourier transform (DTFT)** is one of the specific forms of Fourier analysis. As such, it transforms one function into another, which is called the frequency domain representation, or simply the "DTFT", of the original function (which is often a function in the time-domain). But the DTFT requires an input function that is discrete. Such inputs are often created by sampling a continuous function, like a person's voice.

The DTFT frequency-domain representation is always a periodic function. Since one period of the function contains all of the unique information, it is sometimes convenient to say that the DTFT is a transform to a "finite" frequency-domain (the length of one period), rather than to the entire real line.

Given a discrete set of real or complex numbers: x[n], n∈Z(integer), the discrete-time Fourier transform (DTFT) is written as:

$$X(\omega) = \sum_{n=-\infty}^{\infty} x[n] e^{-i\omega n}$$

The following inverse transforms recovers the discrete-time sequence

$$x[n] = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(\omega).e^{i\omega n} d\omega$$

$$= T \int_{-\frac{1}{2T}}^{\frac{1}{2T}} X_T(f).e^{i\,2\pi f n T} df$$

Since the DTFT involves infinite summations and integrals, it cannot be calculated with a digital computer. Its main use is in theoretical problems as an alternative to the DFT. For instance, suppose you want to find the frequency response of a system from its impulse response. If the impulse response is known as an array of numbers, such as might be obtained from an experimental measurement or computer simulation, a DFT program is run on a computer. This provides the frequency spectrum as another array of numbers, equally spaced between, for example, 0 and 0.6 of the sampling rate. In other cases, the impulse response might be given as an equation, such as a sine function or an exponentially decaying sinusoid. The DTFT is used here to mathematically calculate the frequency domain as another equation, specifyingtheentirecontinuouscurvebetween0and0.6.Whilethe

DFT could also be used for this calculation, it would only provide an equation for samples of the frequency response, not the entire curve.

3.6   Discrete Cosine Transform(DCT)

A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. The cosine transform, like Fourier Transform, uses sinusoidal basis functions. The difference is that the cosine transform basis functions are not complex; they use only cosine functions, and not sine functions. The two-dimensional discrete cosine transform (DCT) equation for an N x N image for an example is as givenby:

$$F(u,v) = C(u)C(v) \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f[m.n] \cos\left(\frac{(2m+1)u\pi}{2N}\right) \cos\left(\frac{(2n+1)v\pi}{2N}\right)$$

for $0 \le u, v < N$

$$C(u) = \begin{cases} \sqrt{1/N} \ for u=0 \\ \sqrt{2/N} \ for u \ne 0 \end{cases}$$

with

We can interpret this as the projection of $f[m,n]$ onto basis functions of the form:

$$e_{u,v}[m,n] = C(u,v) \cos\left(\frac{(2m+1)u\pi}{2N}\right) \cos\left(\frac{(2n+1)v\pi}{2N}\right)$$

Since this transform uses only the cosine function it can be calculated using only real arithmetic, instead of complex arithmetic as the DFT requires. The cosine transform can be derived from the Fourier transform by assuming that the function (the image) is mirrored about the origin, thus making it an even function. Thus, it is symmetric about the origin. This has the effect of canceling the odd terms, which correspond to the sine term (imaginary term) in Fourier transform. This also affects the implied symmetry of the transform, where we now have a function that is implied to be 2N x2N.

Some sample basis functions are shown in Figure 2.2, for a value of
         $N=8$.

Based on the preceding discussions, we can represent an image as a superposition of weighted basis functions (using the inverse DCT):

$$f[m,n] = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} C(u)C(v)F[u,v]\cos\left(\frac{(2m+1)u\pi}{2N}\right)\cos\left(\frac{(2n+1)v\pi}{2N}\right)$$

for $0 \le m,n < N$

with $C(u)=\begin{cases} \sqrt{1/N} \ for\ u=0 \\ \sqrt{2/N} \ for\ u \ne 0 \end{cases}$
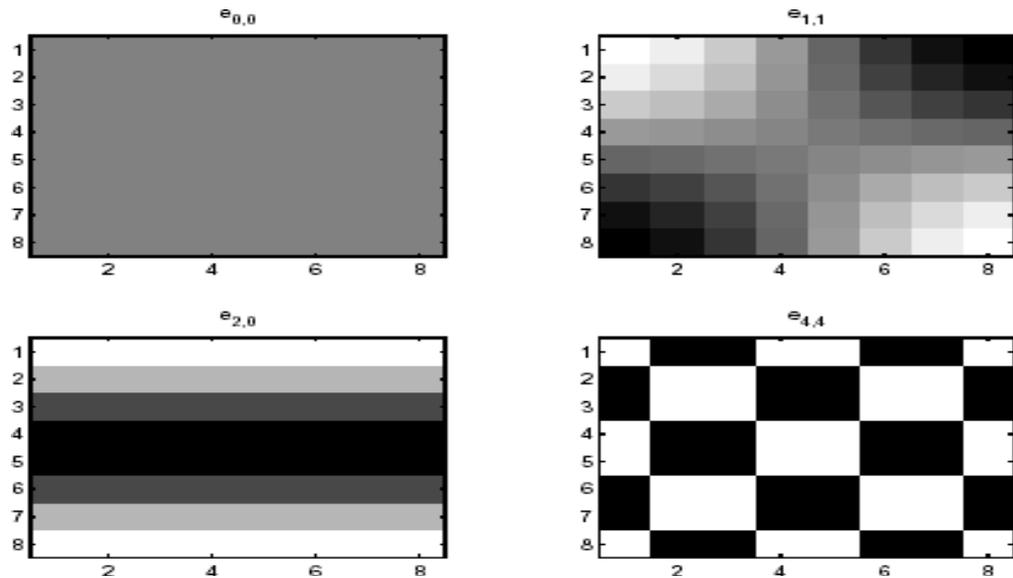
Fig. 2.2: Sample basis functions for an 8x8 block of pixels

The above four have been chosen out of a possible set of 64 basis functions.

This goes to show that DCT coefficients are similar to Fourier series coefficients in that they provide a mechanism for reconstructing the target function from the given set of basic functions. In itself, this is not particularly useful, since there are as many DCT coefficients as there were pixels in the original block. However, it turns out that most real images (natural images) have most of their energy concentrated in the lowest DCT coefficients. This is explained graphically in Figure 2.3 where we show a 32 x 32 pixel version of the test image, and its DCT coefficients. It can be shown that most of the energy is around the (0,0) point in the DCT coefficient plot. This is the motivation for compression

– since the components for high values of u and v are small compared to the others, why not drop them, and simply transmit a subset of DCT coefficients, and reconstruct the image based on these. This is further illustrated in Figure 2.4, where we give the reconstructed 32 x 32 image using a small 10x10 subset of DCT coefficients. As you can see there is little difference between the overall picture of Figure 2.2 (a) and Figure 2.4 , so little information has been lost. However, instead of transmitting 32x32=1024 pixels, we only transmitted 10x10 =100 coefficients, which is a compression ratio of 10.24 to1.
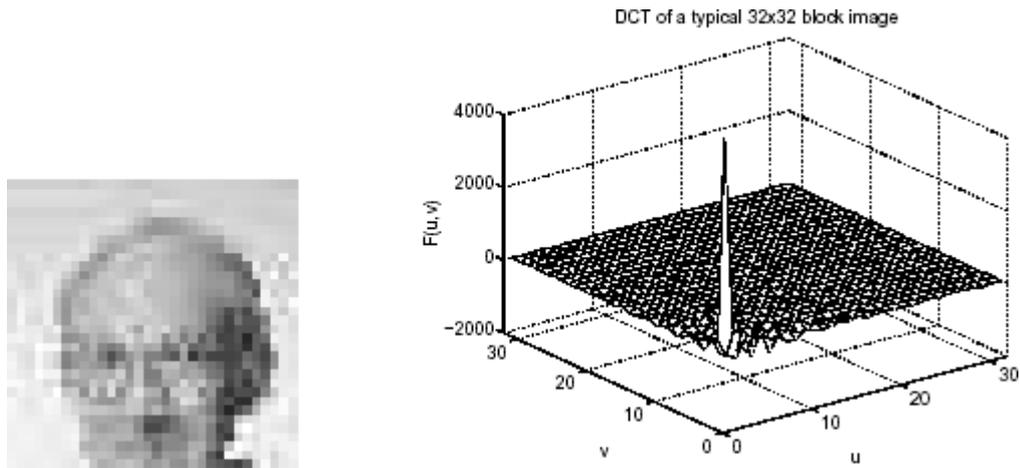
Fig. 2.3: (a) 32 x 32 pixel version of our standard test image. (b)The DCT of thisimage.

Fig. 2.4: 32 x 32 pixel image reconstructed from 10x10 subset of DCT coefficients. Overall information has been retained, butsome detail has beenlost.

An optimal transform for compression would maximise the "energy-compressing" feature of the transform; that is the transform of the image would have most of its energy in the fewest number of coefficients. The DCT is not the optimal transform from this perspective; it can be shown mathematically that a Karhunen-Loeve transform will provide the best basis for compression. However, this optimal basis isimage-dependent

and computationally intensive to find, so it is not commonly used in image compression systems.

DCTs are important to numerous applications in science and engineering, from lossy compression of audio and images (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient whereas for differential equations the cosines express a particular choice of boundary conditions. The DCT is the basis of many widespread image-coding standards: specifically, JPEG, MPEG, and H.26X which are respectively still image, video-playback, and video telephony standards.

4.0 Self-Assessment Exercise(s)

1. What is the factor that makes the DFT so attractive for image processing?

2. What is the significance of fourier transform?
3. State the link between fourier series coefficient and discreet cosine transform coefficient.
4. Give a concise description of the discrete time fourier transform.
5. List three common image-coding standards.
6. Explain two properties of the two-dimensional Fourier transform.

5.0   Conclusion

To wrap up, we discovered that 'Fourier Transform' is of fundamental importance to image processing. It allows us to perform tasks which would be impossible to perform any other way; its efficiency allows us to perform most compression tasks more quickly. The Fourier Transform is a very useful mathematical tool for multimedia processing. The Fourier Transform and the inverse Fourier transforms are the mathematical tools that can be used to switch from one domain to the other.

6.0   Summary

In this unit, we covered the definition of Fourier transforms, types of Fourier Transform and its application in digital image processing.

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UNIT 3   VIDEO AND AUDIOCOMPRESSION

CONTENTS

1.0   Introduction

In this unit, you have a chance to learn another aspect of Multimedia Technology. We will study about video compression. We will equally learn about different audio compressions.

2.0   Intended Learning Outcomes (ILOs)

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

- explain the principle of videocompression
- describe the JPEG algorithmapproach
- examine the application of videocompression
- appreciate the sensitivity of humanhearing
- discuss the notion ofpsychoacoustics.

3.0   MainContent

3.1   Principle of VideoCompression

The principle of still image compression is very similar to that of video compression. Video is simply sequence of digitised picture. Video can also be referred to as moving picture. The terms "frame" and "pictures" are used interchangeably in relation to video. However, we shall use the term frame in relation to videos except where particular standard uses the termpicture.

In principle, one way to compress video source is to apply any of the common algorithms such as JPEG algorithm independently to each frame that makes up a video. This approach is also known as moving JPEG or MPEG. For now typical compression ratios of about 29:1 obtained with JPEG are not large enough to produce the compression ratio needed for multimedia applications.

In practice, in addition to the spatial redundancy present in each frame considerable redundancy is often present between a set of frame since, in general, only a small portion of each frame is involved with any motion that is generally, only a small portion of each frame is involved with any motion that is taking place. For an example, consider the movement of a person's lip or eye in a video telephonyapplication.

3.2   Application of VideoCompression

Haven studied the theory of encoding now let us see how this is applied in practice.

Video (and audio) need to be compressed in practice for the following reasons:

1.   Uncompressed video (and audio) data are huge. In HDTV, the bit rate easily exceeds 1 Gbps. -- big problems for storage and network communications. For example: One of the formats defined for HDTV broadcasting within the United States is 1920 pixels horizontally by 1080 lines vertically, at 30 frames per second. If these numbers are all multiplied together, along with 8 bits for each of the three primary colors, the total data rate required would be approximately 1.5 Gb/sec. Because of the 6 MHz. channel bandwidth allocated, each channel will only support a data rate of 19.2 Mb/sec, which is further reduced to 18 Mb/sec by the fact that the channel must also support audio, transport, and ancillary data information. As can be seen, this restriction in data rate means that the original signal must be compressed by a figure of approximately 83:1. This number seems all the more impressive when it is realised that the intent is to deliver very high quality video to the end user, with as few visible artifacts aspossible.

2.   Lossy methods have to be employed since the *compression ratio* of lossless methods (e.g., Huffman, Arithmetic, LZW) is not high enough for image and video compression, especially when distribution of pixel values is relativelyflat.

The following compression types are commonly used in video compression:

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- Spatial Redundancy Removal - Intraframe coding(JPEG)
- Spatial and Temporal Redundancy Removal - Intraframeand Interframe coding (H.261, MPEG)

3.3   AudioCompression

As with video a number of compression techniques have been applied to audio. We shall consider the common ones in the subsequent units.

3.3.1 Simple AudioCompression

The following are some of the Lossy methods applied to audio compression:

- Silence Compression - detect the "silence", similar to run-length coding
- Adaptive Differential Pulse Code Modulation (ADPCM) e.g., in CCITT G.721 - 16 or 32Kbits/sec
- Encodes the difference between two consecutivesignals
- Adapts at quantisation so fewer bits are used when the value is smaller.
  - It is necessary to predict where the waveform is headed -> difficult
  - Apple has proprietary scheme called ACE/MACE. Lossy scheme that tries to predict where wave will go in next sample. About 2:1compression.
- Linear Predictive Coding (LPC) fits signal to speech model and then transmits parameters of model. Sounds like a computer talking, 2.4kbits/sec
- Code Excited Linear Predictor (CELP) does LPC, but also transmits error term - audio conferencing quality at 4.8kbits/sec.

3.3.2 Psychoacoustics

These methods are related to how humans actually hear sounds

3.4   Human Hearing andVoice

These methods are related to how humans actually hear sounds.

- Range is about 20 Hz to 20 kHz, most sensitive at 2 to 4KHz.
- Dynamic range (quietest to loudest) is about 96dB
- Normal voice range is about 500 Hz to 2kHz
    - Low frequencies are vowels andbass
    - High frequencies areconsonants

Question: How sensitive is human hearing?

- Experiment: Put a person in a quiet room. Raise level of 1kHz tone until just barely audible. Vary the frequency andplot
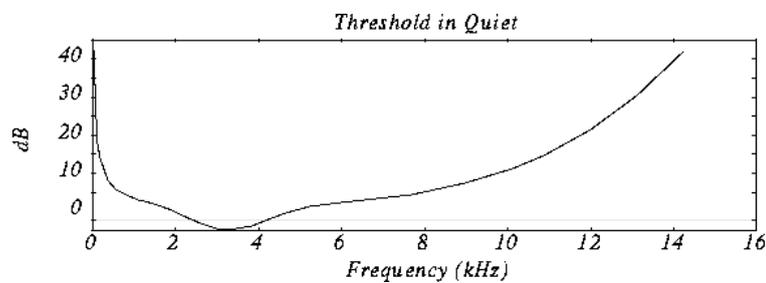
In sum,

- If we have a loud tone at, say, 1 kHz, then nearby quieter tones aremasked
- Best compared on critical band scale - range of masking isabout 1 criticalband
- Two factors for masking - frequency masking andtemporal masking

3.5   Streaming Audio (andVideo)

This is the popular delivery medium for the Web and other Multimedia networks
Examples of streamed audio (and video) (and video)

- RealAudio
- Shockwave
- WAV files (not videoobviously)

If you hYou could try the file was originally recorded at CD Quality (44 Khz, 16-bit Stereo) and is nearly minutes in length.

- The original uncompressed file is about 80Mb.
- The compressed file (at 33.3) is only 1.7 Mb in total and is still of very goodquality.
- The file is downloaded to browser and not steamed above. Whilst real audio players and encoders are freely available (see {\em http://www.realaudio.com/}). Real audio servers {\bf cost money}.
  - BufferedData:
    - Trick get data to destination before it isneeded
    - Temporarily store in memory(buffer)
    - Server keeps feeding thebuffer
    - Client application readsbuffer
  - Needs reliableconnection, moderately fasttoo.
  - Specialized client, Steaming Audio Protocol (PNM for real audio).

□

4.0Self-Assessment Exercise(s)

1. Which compression method is preferable in the image and video compression context?

_____
_____
_____

2. List the common compression techniques used in audio.
3. Give two common examples of streamed audio.
4. State the lossy method applied to audio compression

5.0   Conclusion

In conclusion, video is simply sequence of digitised picture, they can be *compressed.* One way to compress video source is to apply any of the common algorithms such as JPEG algorithm independently to each frame that makes up a video. Normal voice range is about 500 Hz to 2 kHz. Low frequencies are vowels and bass, while high frequencies are consonants.

6.0   Summary

In sum, we learnt about the principle of video compression. We equally discovered the common types of audio compression as well as the phenomenon of human hearing and voice. Some examples of streamed audio (and video) are; real audio, shockwave, .WAV files. Hope you

grasped these key points? You can now attempt the questions below.

7.0   FurtherReadings

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UNIT 4   IMAGE HISTOGRAM ANDPROCESSING

CONTENTS

1.0   Introduction

Image processing is a very important aspect of digital signal processing (DSP). In this unit, we shall explore the application of DSP techniques in the enhancement of images, by applying histogram analysis. We shall equally consider image restoration which is a main relevance of image processing.

2.0   Intended Learning Outcomes (ILOs)

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

• describe the concept of the histogram of animage
• give an overview of imageanalysis
• identify a bi-modalimage
• state two main image enhancementoperators
• explain the notion of imagerestoration
• define the term'noise'.

3.0   MainContent

3.1   Histogram of anImage

In an image processing context, the ***histogram of an image*** normally refers to a histogram of the pixel intensity values. This ***histogram*** is a graph showing the number of pixels in an image at each different intensity value found in that image. For an 8-bit grayscale image there are 256 different possible intensities, and so the histogram will

graphically display 256 numbers showing the distribution of pixels amongst those grayscale values.

Histograms can also be taken of colour images --- eitherindividual histogram of red, green and blue channels can be taken, or a 3-D histogram can be produced, with the three axes representing the red, blue and green channels, and brightness at each point representing the pixel count. The exact output from the operation depends upon the implementation --- it may simply be a picture of the required histogram in a suitable image format, or it may be a data file of some sort representing the histogramstatistics.

ImageAnalysis

The process of image analysis is very simple. The image is scanned in a single pass and a running count of the number of pixels found at each intensity value is recorded. This is then used to construct a suitable histogram.

Histograms have many applications. One of the more common is to decide what value of threshold to employ when converting a grayscale image to a binary one through thresholding. If the image is suitable for thresholding then the histogram will be *bi-modal, i.e.* the pixel intensities will be clustered around two well-separated values. A suitable threshold for separating these two groups will be found somewhere in between the two peaks in the histogram. If the distribution is not like this then it is unlikely that a good segmentation can be produced by thresholding.

The intensity histogram for the input is

is
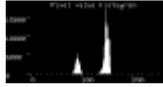
The object being viewed is dark in color and it is placed on a light background, and so the histogram exhibits a good bi-modal distribution. One peak represents the object pixels, one represents the background.
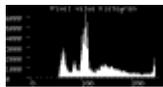
The histogram

is the same, but with the *y*-axis expanded to show more detail. It is clear that a threshold value of around 120 should segment the picture nicely, as can be seen in

The histogram of image

is

This time there is a significant incident illumination gradient across the image, and this blurs out the histogram. The bi-modal distribution has been destroyed and it is no longer possible to select a single global threshold that will neatly segment the object from its background. Two failed thresholding segmentations are shown in

and

using thresholds of 80 and 120, respectively.

It is often helpful to be able to adjust the scale on the *y*-axis of the histogram manually. If the scaling is simply doneautomatically, then

very large peaks may force a scale that makes smaller features indiscernible.

3.2   Image EnhancementOperators

The histogram is used and altered by many image enhancement operators. Two operators which are closely connected to the histogram are *contrast stretching* and *histogram equalisation*. They are based on the assumption that an image has to use the full intensity range to display the maximum contrast. Contrast stretching takes an image in which the intensity values don't span the full intensity range and stretches its values linearly. This can be illustratedwith
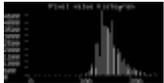

Its histogram
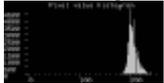
shows that most of the pixels have rather high intensity values. Contrast stretching the image yields

which has a clearly improved contrast. The corresponding histogram is


If we expand the *y*-axis, as was done in

we can see that now the pixel values are distributed over the entire intensity range. Due to the discrete character of the pixel values, we can't increase the number of distinct intensity values. That is the reason why the stretched histogram shows the gaps between the singlevalues. The image

also has low contrast. However, if we look at its histogram,
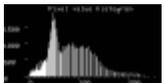
we see that the entire intensity range is used and we therefore cannot apply contrast stretching. On the other hand, the histogram also shows that most of the pixels values are clustered in a rather small area, whereasthetophalfoftheintensityvaluesisusedbyonlyafewpixels.

The idea of **histogram equalisation** is that the pixels should be distributed evenly over the whole intensity range, *i.e.* the aim is to transform the image so that the output image has a *flat* histogram. The image

results from the histogram equalisation and
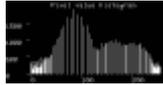
is the corresponding histogram. Due to the discrete character of the intensity values, the histogram is not entirely flat. However, the values are much more evenly distributed than in the original histogram and the contrast in the image was essentially increased.

3.3   ImageRestoration

Image restoration focuses on the removal or reduction of degradations which happened during the acquisition of an image data. The degradations may include noise, which are errors in the pixel values, or optical effects such as out of focus blurring, or blurring due to camera motion. While neighbourhood operations can be used as a dependable technique for image restoration, other techniques require the use of frequency domain processes.

3.3.1 Noise

In image digital signal processing systems, the term noise refers to the degradation in the image signal, caused by external disturbance. If an image is being sent electronically from one place to another, via satellite or through networked cable or other forms of channels we may observe some errors at destination points.

These errors will appear on the image output in different ways depending on the type of disturbance or distortions in the image acquisition and transmission processed. This gives a clue to what type of errors to expect, and hence the type of noise on the image; hence we can choose the most appropriate method for reducing the effects. Cleaning an image corrupted by noise is thus an important aspect of image restoration.

Some of the standard noise forms include:

- Salt and PepperNoise
- Gaussain Noise

And provide some details on the different approaches to eliminating or reducing their effects on the image.

3.3.2 NoiseReduction

Now that we have identified the sources of noise in digital signals and some types of noise, we shall describe some of the techniques of reducing or eliminating noise in the image processing. On a general note filters can be used to remove or eliminate noise in an image. The energy of a typical image is primarily in the low frequency region; therefore, a (two-dimensional) low-pass filtering will be good enough in removing a substantial amount of uniform random noise though not without removing some details of the image. On the other hand, the edges that exist in an image usually produce high frequency components. If these components are removed or reduced in energy, the edges will become fuzzier. Median filter is ideal in removing impulse noise while preserving the edges.

They are non-linear filters however, and therefore the process cannot be reversed. In median filtering, a window or mask slides along the image. This window defines a local area around the pixel being processed. The median intensity value of the pixel within that window becomes the new intensity value of the pixel being processed.

4.0 Self-Assessment Exercise(s)

7. Describe the histogram of an image

_____
_____
_____

2. Give an overview of image analysis.

3   When is an image said to be bi-modal?
4   State two main image enhancement operators.
5   Define the term 'noise.'

5.0   Conclusion

To wrap up, recall the following: In an image processing context, the *histogram of an image* normally refers to a histogram of the pixel intensity values. Two operators which are closely connected to the histogram are *contrast stretching* and *histogram equalisation*. *Image restoration* focuses on the removal or reduction of degradations which happened during the acquisition of an image data. Remember that with more practise, you will acquire skills for advanced Multimedia Technology. All the best!

6.0   Summary

In this unit we discovered that image processing is a very important aspect of digital signal processing (DSP). We also explored the application of DSP techniques in the enhancement of images, by applying histogram analysis as well as image restoration. Let us now attempt the questions below.

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