Multimedia Revision

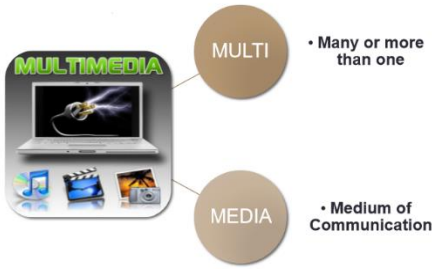
https://github/AhmedKhalil777

In The Name Of ALLAH

Module 1 (Intro to Multimedia)

- Every One has a different **Viewpoint** for "Multimedia" Word:
  - **PC Vendor**: as a collection of **HW** devices (Sound Capability - DVD Rom – and Perhaps understand that they have Microprocessor Capabilities)
  - **Consumer for Entertainment**: as a **TV** with hundreds of Channels
  - **CS Student**: ***Application*** that use multiple **modalities (Images , Text , animation , Video , interactivity)**

Multi (multus) : "**numerous, multiple**"
Media (medium): "**middle, center**" (hardware + software) used for **dissemination** (distribute) and **representation of information**
usage of multiple **agents (text, audio, video, images)** for disseminating and presenting information to audience
simultaneous use of more than one medium
better name is "Integrated media".



Multimedia Consists of

all applications that involve a combined use of **different kinds of media**

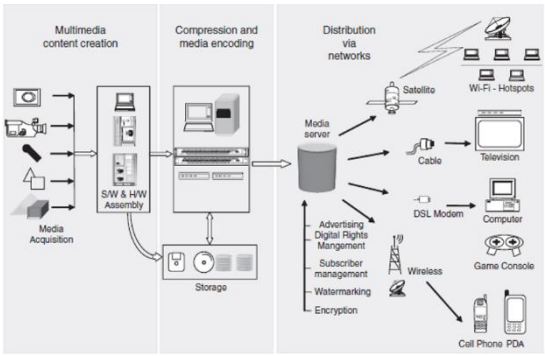
- The Presentation that use them Called => **Multimedia Presentation**
- The Software also use them => **Multimedia Software**
- System ….. => **Multimedia System**

Multimedia Application is an application which uses a collection of multiple media sources like (— World Wide Web, — Multimedia Authoring, e.g. Adobe/Macromedia Director, — Video-on-demand, — Interactive TV, — Computer Games, — Digital video editing and production systems, — Multimedia Database systems.)

- **Business: (Sales / Marketing Presentation Trade show production Staff Training Application Company Kiosk)**
- **Education: (Courseware / Simulations E-Learning / Distance Learning , Information Searching)**
- **Entertainment: (Games (Leisure / Educational) , Movies , Video on Demand)**
- **Public places: Information Kiosk , Smart Cards, Security**
- **Home : Television Satellite TV , SMS services (chats, voting, reality TV)**

Multimedia System: A system that involves generation, representation, storage, transmission, search and retrieval, and delivery of multimedia information => 3 Processes inherent to these systems:

- **Multimedia content creation or multimedia authoring:** digitizing media
  - variety of different instruments, which capture different media types in a digital format.
  -
- **Storage and compression:** minimize necessities for storage and distribution
- **Distribution :** distribution across a variety of low bandwidth and high-bandwidth networks.



- Distribution normally follows **standards protocols**, which are responsible for **collating and reliably** sending information to end receivers.

Inherent Qualities of Multimedia Data

- **Digital**: digital nature allows it to be combined together to produce rich content.
- **Voluminous**: **size** of the data resulting from combining these medias is **Large** and **Voluminous** => we need **compression techniques => Care of** storage and transmission bandwidth limitations
- **Interactive:** many options to do with the same multimedia e.g you can click on areas of an image causing an action to be taken, Web site consisting of hyperlinked text**.**
- **Real-time and synchronization:** need much transmission speed Real-time => can be only **a very small** and bounded delay while transmitting information

Different Media Types Used Today

- Text:
  - commonly used to express information
  - text information has evolved from simple text to more meaningful and easy-to-read formatted text
  - **hypertext** is commonly used in digital documents, allowing **nonlinear access to information**.
  - **Linear multimedia:** active content progresses without any navigation control for the viewer such as a cinema presentation or movie.
  - **Non-linear multimedia**: user interactivity, such as selection buttons or hyperlinks, to control progress as used with a computer game or used in self-paced computer-based training.
  - Non-linear content is also known as hypermedia content.
- Image:
  - consist of a set of units called pixels => 2 dimensional array (Width - Height) => the same bit depth for each pixel in the same image.
  - **Bit depth** : number of bits assigned to each pixel. => control the level of colors and types (monochrome , intensity , color image , indexed images)
  - **Size = Width * Height * Bit Depth.**
  - **Formats :** application-specific (jpeg , png , faxes , ……)
  - **Dimensionality:** singularly or combined => just an image or stereo image (Panoramas)
- Video**:**
  - represented as a sequence of images
  - Width , Height , Pixel Depth , frames per second or fps.
  - **Size = W * H * pixel Depth * frames per second * duration of video**
  - **Aspect ratio:** The ratio of the Width: Height=> common aspect ratio for video is 4:3, High Definition 16:9
  - 

  - **Scanning format:** convert the frames of video into a one-dimensional signal for broadcast.
    - **Interlaced scanning:** Scanning odd rows then even's , Flickers problem **(The Middle of Last Century 1950's)**
    - **progressive scanning:** all rows scanned on one frame, Better quality
    - 

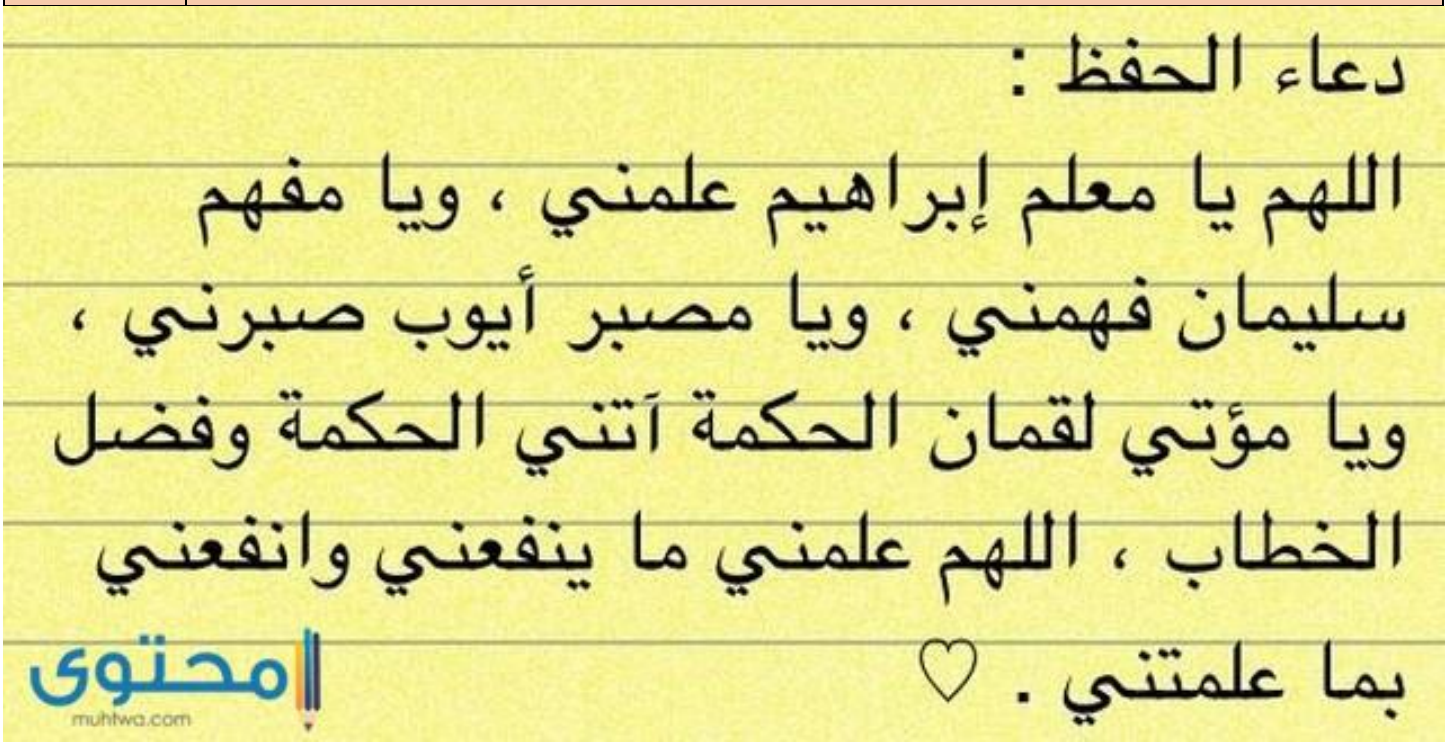
- 2D Graphics:
  - commonplace in multimedia presentations

- represented by **2D vector** coordinates and normally has properties such as a fill color, boundary thickness, and so on.
- effectively used to create 2D animations **to better illustrate information**.

- 3D Graphics:
  - used today for **high-end content** in movies, computer games, and advertising.
  - have advanced considerably as a science

Table 1.1 Classification of Multimedia Systems

Static	○ multimedia data remains the same within a certain finite time ○ slide of a Microsoft PowerPoint presentation or one HTML Web page.
Dynamic	○ data is changing like watching a video
Real-time	○ Playing online shooting games Pubg , Watching Youtube
orchestrated	○ refers to cases when there is no real-time requirement. ○ compressing content on a DVD and distributing it. Common for download the media
Linear	○ proceed **linearly** through the information ○ reading an eBook or watching a video.
Non-Linear	○ make **use of links** that map one part of the data to another. ○ The term hypermedia generalizes the concept of accessing media nonlinearly.
Person-to-machine vs person-to-person	the end user is interacting with a machine or with another person.
Single user, peer-to-peer, peer-to-multipeer, and broadcast	○ Just me , Unicast , Multicast , Broadcast ○ the manner of information distribution. ○ **Broadcasting** is the most **general-purpose scenario**, where information is sent not to any specific listener(s) but available to all those who want to listen, such as television and radio broadcasts.



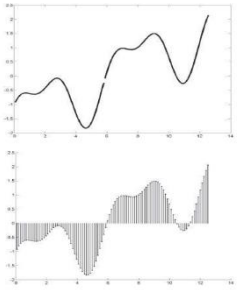
Module 2 "Digital Data Acquisition"

- **Digitizing process(analog-to Digital process)**: Convert the analog signals to digital signals
- This process for recording of information into a digital medium to ease filtration, compression, and distribution.
- physical world around us exists in a continuous form(light, sound energy, pressure, temperature, motion)
- **Recording instruments**: such as cameras, camcorders, microphones, gauges, and so on, attempt to **measure information** in an electrical and digital form.
    - **digital camera** contains => CCD (Coupled charged Device) array of sensors that release an electric charge that is proportional to the amount of light energy falling on it. (the more energy, the higher the charge)
- **Quality and the Quantity:** are important to the creation and distribution of multimedia
    - More Quantity seems you need much Bandwidth and storage and but generate more Quality

We digitized the media as

- 1-dimansional => audio (amplitudes)
- 2-dimansional => image (width and height)
- 3-dimansional => videos (Frames dimensions and the (width and height))

Analog and Digital Signals



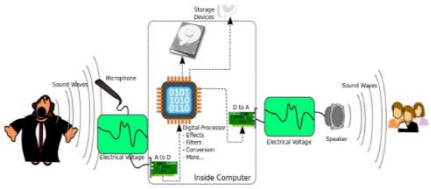
- **Analog signals** are captured by a recording device => as a Physical Signal represented by a continuous function
    - encode the changing amplitude with respect to an input dimension(s)
- **Digital signals** are represented by a discrete set of values defined at specific instances of the input domain, which might be time, space, or both.

Advantages of Digital Signals over Analog one

- We can create complex, interactive content from digital signal.
- In the digital medium, we can access each unit of information for a media type.
    - access a pixel in an image, or a group of pixels
    - Different digital operations can be applied => enhance the image quality of a region or remove noise in a sound track.
    - combined or composited to create richer content, which is not easy in the analog medium.
- Stored digital signals do not degrade over time
    - Drawbacks of analog storing is **Ghosting** in VHS tapes => repeated usage and degradation of the medium over time.
- Digital data can be efficiently **compressed and transmitted** across digital networks.
- easy to store digital data on magnetic media (portable 3.5 inch, hard drives, or solid state memory devices)

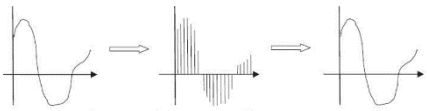
> ***digital data*** is preferred because it offers **better quality** and **higher fidelity**, can be easily used to create **compelling content**, and can also be **compressed, distributed, stored, and retrieved relatively** easily.

Analog to digital conversion

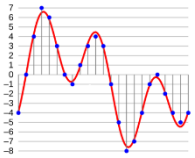


1. First must convert from Analog to Digital Signal may be stored or transmitted may be altered through digital signal processing(filtered or have effects applied).
    a. Audio data compression techniques (MP3, or Advanced Audio Coding) to reduce the file size =>Digital audio can be streamed to other devices.
2. converted back to an analog signal with a DAC.

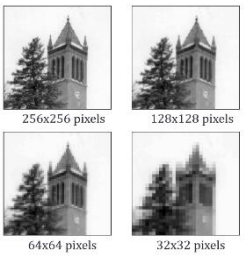
- Computers work with **discrete pieces** of information
- The conversion of signals from **analog to digital** occurs
  - Sampling
  - Quantization
- **Interpolation : The Reverse operation (Digital to Analog Converting)**
- ensure that no artifacts are created in the digital data is desirable property.
  - converted back to the analog domain, it will look the same as the original analog signal.



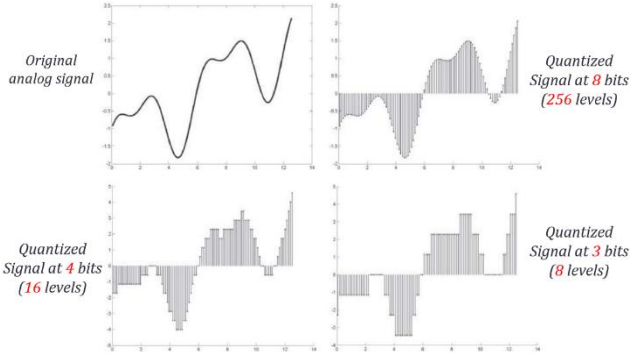
- To convert an image to digital form, we have to sample the function in both coordinates and in amplitude.
  - **Sampling**: Digitizing the coordinate values
  - **Quantization**: Digitizing the amplitude values

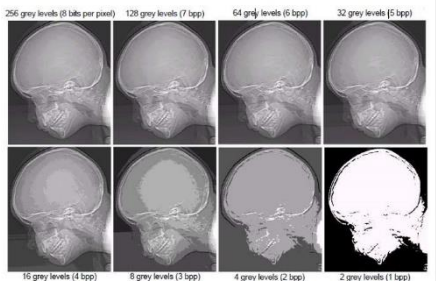


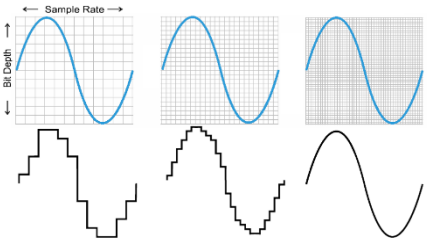
- **sampling** is done across
  - one dimension (time, for sound signals)
  - two dimensions (spatial x and y, for images)
  - three dimensions (x, y, time for video).
  - one-dimensional analog signal in the time t domain, with an amplitude given by $x(t)$.where T is the time interval between samples , f is sampling rate = no of samples per second
  - **reduce T (increase f)** vice versa.
  - If T is too large, the signal might be under sampled, leading to artifacts
    - Lower sampling rate, allow less quality, less information and we will use less storage space and transmission will be faster.
  - If T is too small, the signal requires large amounts of storage, which might be redundant.
    - Higher sampling rates allow the image to be more accurately represented and more storage.



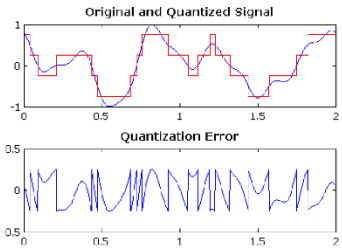
- **Quantization:** encoding the **signal value** at every **sampled location** with a **predefined precision**, defined by a **number of levels**.
  - $xq(n) = Q[xs(n)]$
    - Q represents a **rounding function** that maps the **continuous value** $xs(n)$ to the nearest digital value using b bits.
    - **Levels $N = 2^b$**
    - entire range (R)
    - quantization step $delta = R/2^b$.
  - quantization of a sample value is dependent on the **number of bits** used to represent the **amplitude**
  - The greater the number of bits used, the better the resolution, but the more storage space is required.
  - Quantization - divide the vertical axis (amplitude) **into pieces**.
    - 8 bit quantization divides the vertical axis into 256 levels.
    - 16 bit gives you 65536 levels.
  - value of each sample is rounded off to the nearest integer (quantization).
  - **error increases** as the number of quantization bits used to represent the pixel samples decreases
  - **False contouring effect** is quite visible in images displayed using 16 or less gray levels.



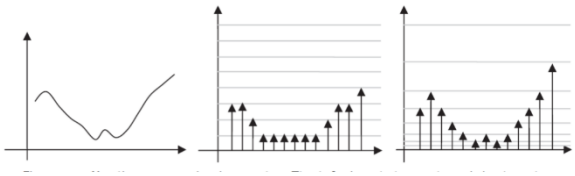




- **Bit depth (sample size):** The number of bits required to represent the value of each sample.
- the quantized value will differ from the actual signal value, thus always introducing an error. => Rounding function
- The **error decreases** as the number of bits used to represent the **sample increases => unavoidable and irreversible loss.**
- how many bits should be used to represent each sample? Is this number the same for all signals?
  - depends on the type of signal and what its intended use is.
  - **Audio signals**, which represent music, must be quantized on **16 bits** . Musical instruments
  - **Speech** only requires **8 bits**. Just Human Voice



- **uniform quantization: intervals** in which the **output range** of the signal is **divided into fixed** and **uniformly separated intervals** depending on the **number of bits** used.=> بيتقطع المحور الى مقاطع متساوية
- **Nonuniform quantization schemes:** the distribution of all output values is **nonuniform**.
  - it is more correct to distribute the quantization intervals nonuniformly.
  - Because the distribution of output values in such signals **is not uniform** over the entire **dynamic range.**
  - **quantization errors** should also be distributed nonuniformly**.**



- **Bit rate** describes the number of bits being produced per second
  - critical **importance** when it comes to **storing a digital signal**, or **transmitting it across networks**
  - Bit Rate = $\frac{Bits}{Second} = \frac{Sample\ produced}{second} = \frac{Bits}{Sample} = Sample\ rate * Quantization\ bits\ per\ sample$
  - the bit rate should be just **right to capture** or convey the necessary information with **minimal perceptual distortion**, while also **minimizing storage requirements**

Sampling theorem and aliasing

- The **rate** at which sampling **should occur**.
- The value of a **nonstatic** signal keeps changing depending on its frequency content.=> Captured not like Sinusoidal waves
- Theoretically => Nyquist Theory
  - if a signal is sampled at **more than twice** its **highest frequency** component, then it can be **reconstructed** exactly from its samples.
  - if it is sampled at less than that frequency (called **undersampling**), then **aliasing will result**.
  - **Aliasing** is the term used to describe loss of information during digitization.
  - This causes **frequencies to appear** in the sampled signal that **were not** in the original signal.
  - we must use a sampling rate equal to at least **twice the maximum frequency** content in the signal. This rate is called **the Nyquist rate**.

Example 1: In a digital telephone system, the speech signal is sampled 8 kHz. What is the sampling period?

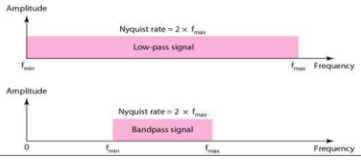
Solution:

$$T_s = 1/f_s = 1/8000 = 0.000125\ s$$

Example 2: What would be the **minimum sampling rate** needed to accurately capture the human voice signal? (Highest voice component 3000 Hz)

Solution:

Minimum sampling rate: $f_s = 2 \times 3000\ Hz = 6000\ Hz$



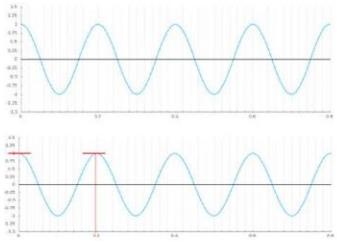
Example 3: A complex ***low-pass*** signal has a bandwidth of 200 kHz. What is the minimum sampling rate for this signal?
Solution:
The bandwidth of a low-pass signal is between **0** and f, **where f is the maximum frequency** in the signal. Therefore, we can sample this signal at 2 times the highest frequency
➔ The sampling rate is therefore 400,000 samples per second.

Example 4: If a signal is **band-limited** with a lower limit "5 KHZ" and an upper limit "12 KHZ" of frequency components in the signal, the sampling rate should be at least .....
Solution:

$$f_{max} = 12 - 5 = 7\ kHz$$

Minimum sampling rate: $f_s = 2 \times 7000\ Hz = 14000\ Hz$

Example 6: Consider a pure sine wave, find the optimum sampling rate
Solution:



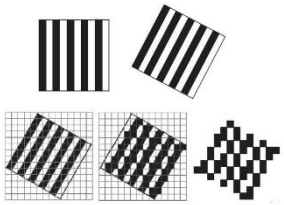
$$f_{max} = 1/T = 1/0.2 = 5\ Hz$$

Sampling rate: $f_s = 2 \times f_{max} = 10\ samples/second$

$$T_s = 1/f_s = 1/10 = 0.1\ \text{sec}$$

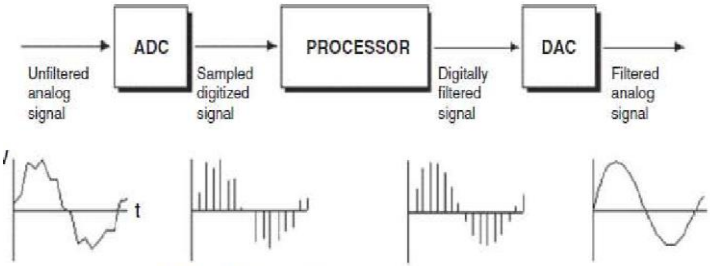
Aliasing in Spatial Domains

- Aliasing effects in the spatial domain are seen in **all dimensions**.
- fewer samples display increased effects of **blur**
- example of aliasing, called the **moiré effectis** a pattern in the image being photographed, and the **sampling rate** for the digital image is **not high enough** to capture the **frequency of the pattern.**



Filtering

- (a signal processing function) filter is to => remove unwanted parts of the signal
  - Removing random noise and undesired frequencies, and to extract useful parts of the signal
- There are two main kinds of filters: **analog and digital**.
  - **analog filter** uses **analog electronic circuits** made up from components such as resistors, capacitors, and operational amplifiers (op-amps) to produce the required filtering effect. => using circuits like noise reduction
  - **digital filter**, on the other hand, uses digital numerical computations on sampled, quantized values of the signal. => using of a pc or digital signal processor (DSP) chip.



- There are 2 type of frequency component in the signal:
  - **High frequency component** are characterized by large changes in values over small distance.
    - Example: noise and edge
  - **Low frequency component** are characterized by little changes in values over small distance.
    - Example: backgrounds, skin texture
- **Low-pass filters** remove high frequency content from the input signal. Such filters are used to avoid **aliasing artifacts** while sampling. Used for blurring and noise reduction.
- **High-pass filters**, remove the **low-frequency** content and are used to **enhance edges and sharpen an image**.
- **Band-pass filters** output signals **containing the frequencies belonging to a defined band.**