# Multimedia Data Basics

Multimedia systems/applications have to deal with the

- Generation of data,

- Manipulation of data,

- Storage of data,

- Presentation of data, and

- Communication of information/data

**Lets consider some broad implications of the above**

# Discrete v Continuous Media

**RECALL**: Our Definition of Multimedia

- All data must be in the form of digital information.

- The data may be in a variety of formats:

  - text,
  - graphics,
  - images,
  - audio,
  - video.

# Synchronisation

A majority of this data is large and the different media may need **synchronisation**:

- The data will usually have temporal relationships as an integral property.



*Click here or image above to run movie*

# Static and Continuous Media

**Static** or **Discrete** **Media** — Some media is time independent:
   Normal data, text, single images, graphics are examples.

**Continuous** **media** — Time dependent Media:
   Video, animation and audio are examples.

# Analog and Digital Signals

- Some basic definitions – **Studied HERE**

- Overviewing of technology — **Studied HERE**

- **More in depth study later.**

# Analog and Digital Signal Conversion

The world we sense is full of analog signals:

- Electrical sensors convert the medium they sense into electrical signals

    – *E.g.* transducers, thermocouples (temperature sensor), microphones (acoustic sensor).

    – (usually) **continuous** signals

- *Analog*: continuous signals must be converted or **digitised** for computer processing.

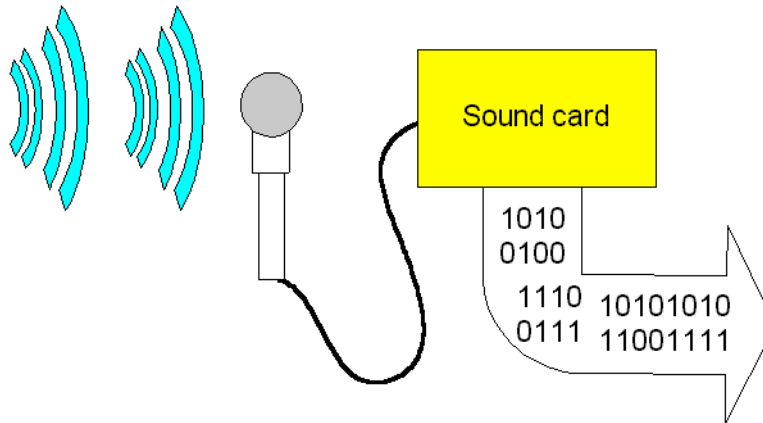- *Digital*: discrete digital signals that computer can readily deal with.
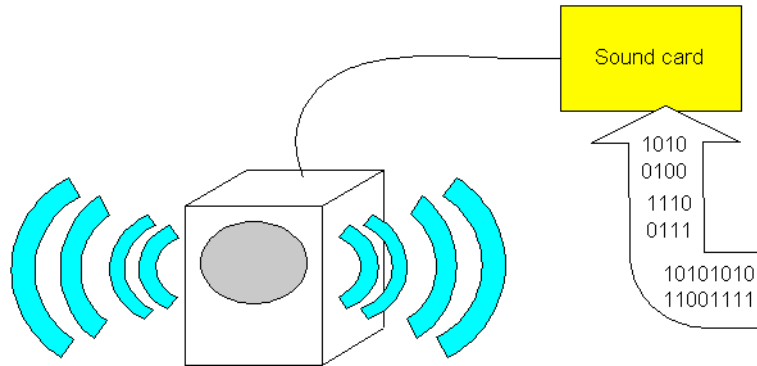
# Analog-to-Digital Converter (ADC)

• Special hardware devices : **Analog-to-Digital** converters



Take analog signals from analog sensor (*e.g.* microphone)
and digitally sample data
(More details later)

# Digital-to-Analog Converter (DAC)

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- Playback – a converse operation to *Analog-to-Digital*



- Takes digital signal, possible after modification by computer (*e.g.* volume change, equalisation)

- Outputs an analog signal that may be played by analog output device (*e.g.* loudspeaker, CRT display)

# Analog-to-Digital-to-Analog Pipeline (1)

- Begins at the conversion from the analog input and ends at the conversion from the output of the processing system to the analog output as shown:
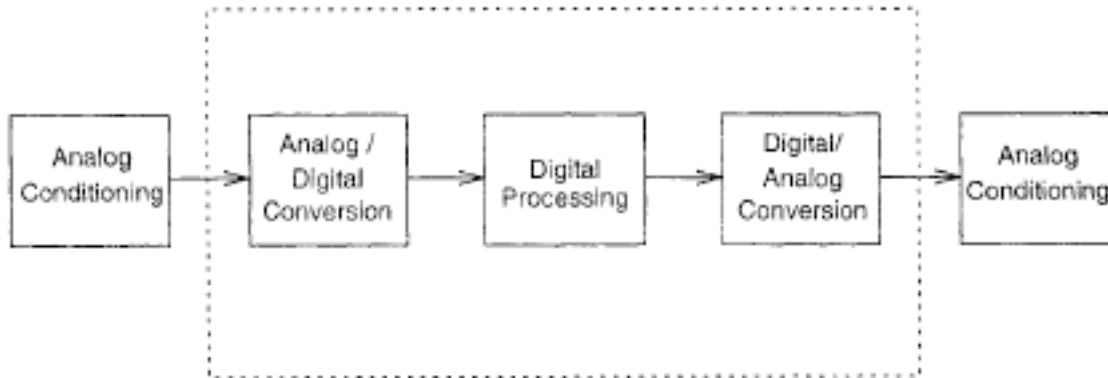


(Strictly Analog-to-Digital-to-Analog is within the dotted box)

# Analog-to-Digital-to-Analog Pipeline (2)

- Anti-aliasing filters (major part of *Analog Conditioning*) are needed at the input to remove frequencies above the sampling limit that would result in *aliasing*. **More later**
  The anti-aliasing filter at the output removes the aliases that result from the sampling theorem.

- After the anti-aliasing filter, the analog/digital converter (ADC) quantises the continuous input into discrete levels.

- After digital processing, the output of the system is given to a digital/analog converter (DAC) which converts the discrete levels into continuous voltages or currents.

- This output must also be filtered with a low pass filter to remove the aliases from the sampling.
  Subsequent processing can include further filtering, mixing, or other operations.
  However, these shall not be discussed further in this course.

# Multimedia Data: Input and format

**How to capture and store each Media format?**

Note that text and graphics (and some images) are mainly generated directly by computer/device (e.g. drawing/painting programs) and *do not* require digitising:

**They are generated directly in some (usually binary) format.**

- Printed text and some handwritten text can be scanned via Optical Character Recognition

- Handwritten text could also be digitised by electronic pen sensing

- Printed imagery/graphics can be flatbed scanned directly to image formats.

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# Text and Static Data

- Source: keyboard, speech input, optical character recognition, data stored on disk.

- Stored and input character by character:

  - Storage: 1 byte per character (text or format character), *e.g.* ASCII; more bytes for Unicode.
  - For other forms of data (*e.g.* Spreadsheet files). May store as text (with formatting, e.g. CSV – Comma-Separated Values) or may use binary encoding.

## Text and Static Data (cont.)

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- Formatted Text: Raw text or formatted text *e.g* HTML, Rich Text Format (RTF), Word or a program language source (C, Java, *etc.*

- Data **Not temporal** — **BUT** may have natural implied sequence *e.g.* HTML format sequence, Sequence of Java program statements.

- Size Not significant w.r.t. other Multimedia data formats.

- Compression: convenient to bundle files for archiving and transmission of larger files. *E.g. Zip, RAR, 7-zip.* General purpose compression programs may not work well for other media types: audio, image, video etc.
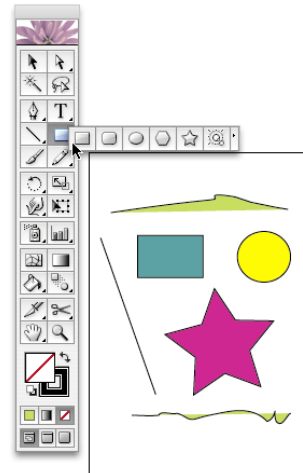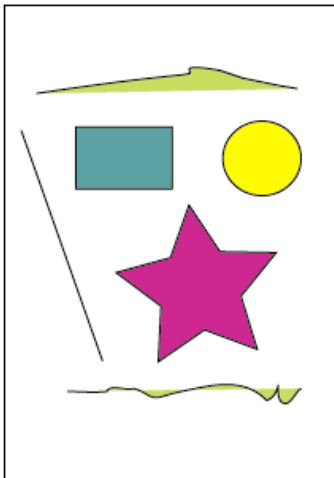
# Graphics

- Format: constructed by the composition of primitive objects such as lines, polygons, circles, curves and arcs.

- Input: Graphics are usually generated by a graphics editor program (*e.g.* Illustrator, Freehand) or automatically by a program (*e.g.* Postscript).
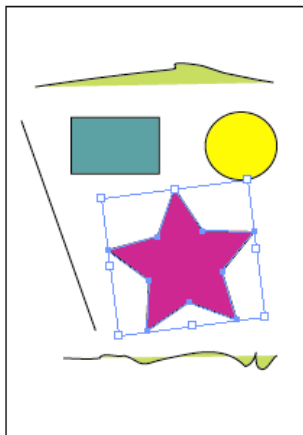
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# Graphics (cont.)

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

- Graphics are usually selectable and editable or revisable (unlike images).



- Graphics files usually store the primitive assembly

- Do not take up a very high storage overhead.

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# Graphics (cont.)

- Graphics standards : OpenGL - Open Graphics Library, a standard specification defining a *cross-language*, *cross-platform* API for writing applications that produce 2D/3D graphics.

- Animation: can be generated via a sequence of slightly changed graphics

  – 2D animation: e.g. Flash. Key frame interpolation. *tweening*: motion; shape
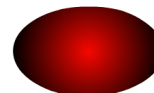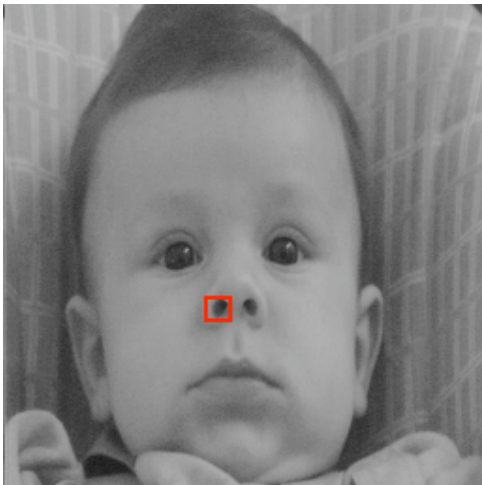
# Graphics (cont.)

- Animation (cont.)

  - 3D animation: e.g. Maya.
    Change of *shape/texture/position, lighting, camera*

- Graphics animation is *compact*
  - suitable for network transmission (e.g. Flash).



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# Images

- Still pictures which (uncompressed) are represented as a bitmap (a grid of pixels).

| 99 | 71 | 61 | 51 | 49 | 40 | 35 | 53 | 86 | 99 |
| 93 | 74 | 53 | 56 | 48 | 46 | 48 | 72 | 85 | 102 |
| 101 | 69 | 57 | 53 | 54 | 52 | 64 | 82 | 88 | 101 |
| 107 | 82 | 64 | 63 | 59 | 60 | 81 | 90 | 93 | 100 |
| 114 | 93 | 76 | 69 | 72 | 85 | 94 | 99 | 95 | 99 |
| 117 | 108 | 94 | 92 | 97 | 101 | 100 | 108 | 105 | 99 |
| 116 | 114 | 109 | 106 | 105 | 108 | 108 | 102 | 107 | 110 |
| 115 | 113 | 109 | 114 | 111 | 111 | 113 | 108 | 111 | 115 |
| 110 | 113 | 111 | 109 | 106 | 108 | 110 | 115 | 120 | 122 |
| 103 | 107 | 106 | 108 | 109 | 114 | 120 | 124 | 124 | 132 |

# Images (cont.)

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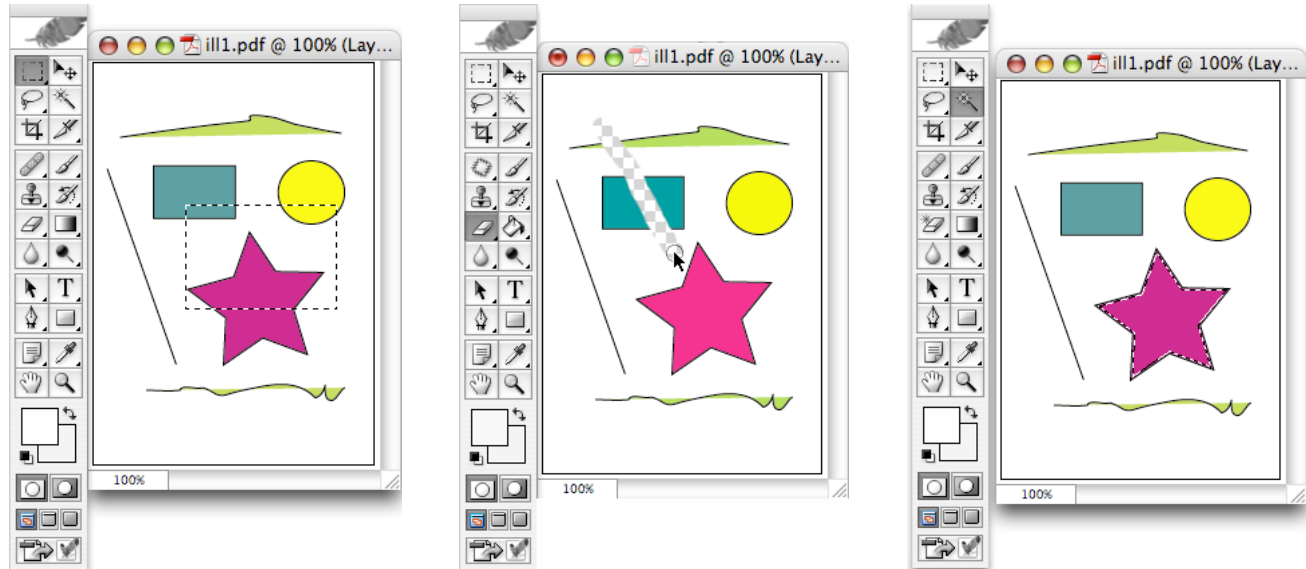
- Input: scanned for photographs or pictures using a digital scanner or from a digital camera.

- Input: May also be generated by programs similar to graphics or animation programs.

- Analog sources will require digitising.

- Stored at 1 bit per pixel (Black and White), 8 Bits per pixel (Grey Scale, Colour Map) or 24 Bits per pixel (True Colour)

- Size: a 512x512 Grey scale image takes up 1/4 MB, a 512x512 24 bit image takes 3/4 MB with no compression.

- This overhead soon increases with image size — modern high digital camera $10+$ Megapixels $\approx$ 29MB uncompressed!
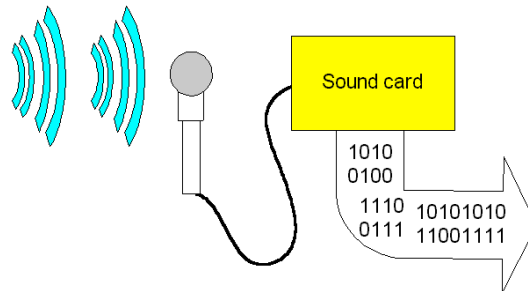
- Compression is commonly applied.

# Images (cont.)

- Can usually only edit individual or groups of pixels in an image editing application, *e.g.* photoshop.

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# Audio

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- Audio signals are continuous analog signals.

- Input: microphones and then digitised and stored



- CD Quality Audio requires 16-bit sampling at 44.1 KHz: Even higher audiophile rates (e.g. 24-bit, 96 KHz)

- 1 Minute of Mono CD quality (uncompressed) audio = 5 MB. Stereo CD quality (uncompressed) audio = 10 MB.

- Usually compressed (E.g. MP3, AAC, Flac, Ogg Vorbis)

# Video

- Input: Analog Video is usually captured by a video camera and then digitised, although digital video cameras now essentially perform both tasks.

- There are a variety of video (analog and digital) formats (**more later**)

- Raw video can be regarded as being a series of single images. There are typically 25, 30 or 50 frames per second.
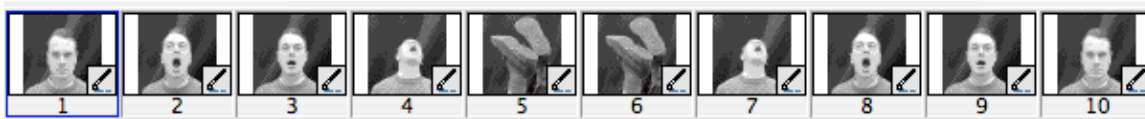


*Click here or image above to run movie*

**Video (cont)**

**Video Size:**

- A 512x512 size monochrome video images take

  25*0.25 = 6.25MB

  for a second to store uncompressed.
- Typical PAL digital video ($720 \times 576$ pixels per colour frame) $\approx 1.2 \times 25 = $ **30MB** for a second to store uncompressed.
- High Definition video on Blu-ray (up to $1920 \times 1080 = $ 2 Megapixels per frame) $\approx 6 \times 25 = $ **150MB** for a second to store uncompressed, i.e. 9GB for a minute to store uncompressed. (There are higher possible frame rates!)
- Digital video clearly needs to be compressed.

# Multimedia Data Representation

Issues to be covered (Over next few lectures):

- Digital Audio

  - Digital Audio Synthesis
  - MIDI — Synthesis and Compression Control
  - Digital Audio Signal Processing/Audio Effects

- Graphics/Image Formats

  - Colour Representation/Human Colour Perception

- Digital Video

  - Chroma Subsampling

# General Themes across all above

- Sampling/Digitisation
  - Sampling Artifacts — *Aliasing*
- Compression requirements
  - Data formats especially size
  - Human Perception $\rightarrow$ compression ideas

**Building up to full Multimedia Compression Algorithms — following lectures**