Basics of digital images & associated sounds

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Why such a title ???

Why basics ?

Apart from the very specialists, who, among films archives, will stand up and say : I know all about it ? (I am not a specialist and I hope that Mr Csaba Gazsi, who is one of them, will forgive me for my poor knowledge of all these complex processes)

Why basics of digital images and associated sounds ?

Why not : basics of digital moving images … ?

When speaking of digital … we speak of many different things. Digital processes for paintings, printed documents, even still photos, are slightly different. It is necessary to understand some of these in order to get the idea about moving images.

Why associated sounds ? What we care for in film archives are the sounds associated with films. Pure audio recordings, having no link with film material are to be analysed and treated differently

What digital means ?

As we are going to see : many different things

Digital compared to analogue

0 and 1 versus waves

Pixel or electric intensity

CD Rom, floppy disc or piece of film

Digital sound that can be copied many generations without any loss

Another way of considering the problem : digital world versus analogue world

- Film archives are more and more confronted to digital technology (for treatments and restoration, for access and for preservation)
- Processes and terminology are different
- Film archivists need to better understand what "digital" means
- Different meanings and approaches depending on the media (data, printed materials, films, video and sounds)

Basics of digital in relation to still images and printed documents

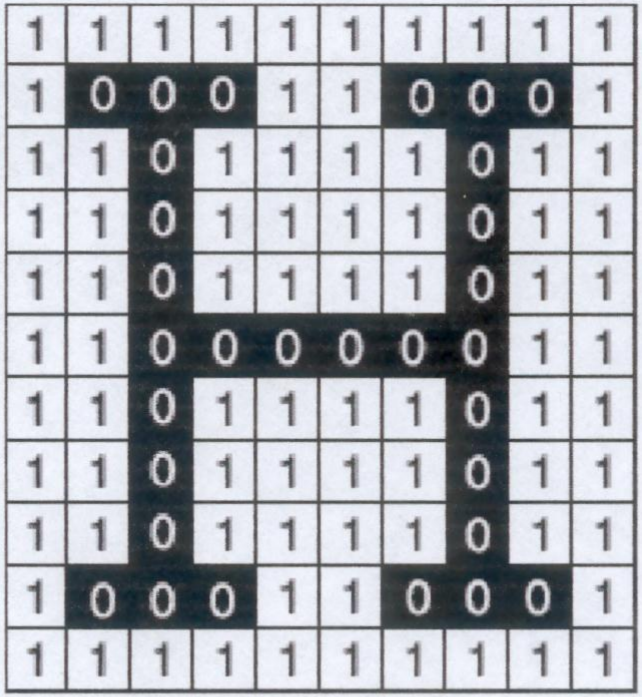
First step of basic understanding
Terminology is based on key concepts

Key concepts

Digital images : what are they ?

- Electronic photo of a scene or scanned capture of documents (photographs, books, artworks …). Specific aspects of films, video and sounds > 2nd part
- Image is sampled and mapped as a grid of dots or picture elements : **pixels**

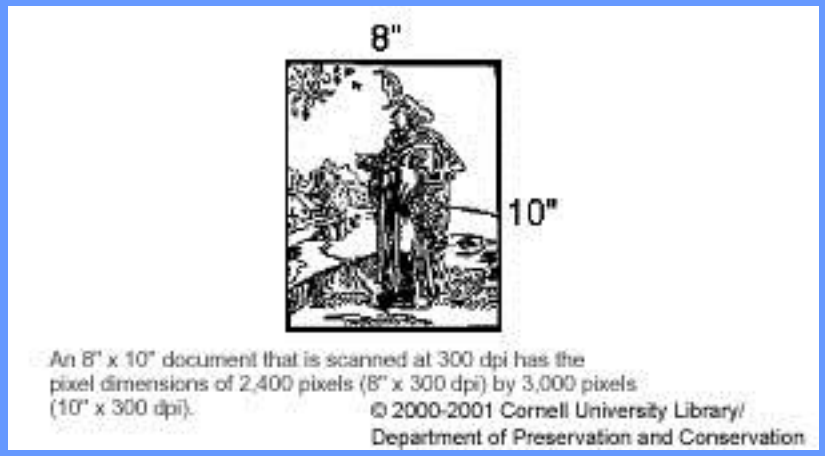
Pixels



Pixel Values: As shown in this bitonal image, each pixel is assigned a tonal value, in this example 0 for black and 1 for white.

Each pixel is assigned a tonal value : black, white, shades of gray or color represented in **binary** code (0 and 1). Binary digits (**bits**) for each pixel are stored in a sequence by a computer and often reduced to a mathematical representation (**compressed**).

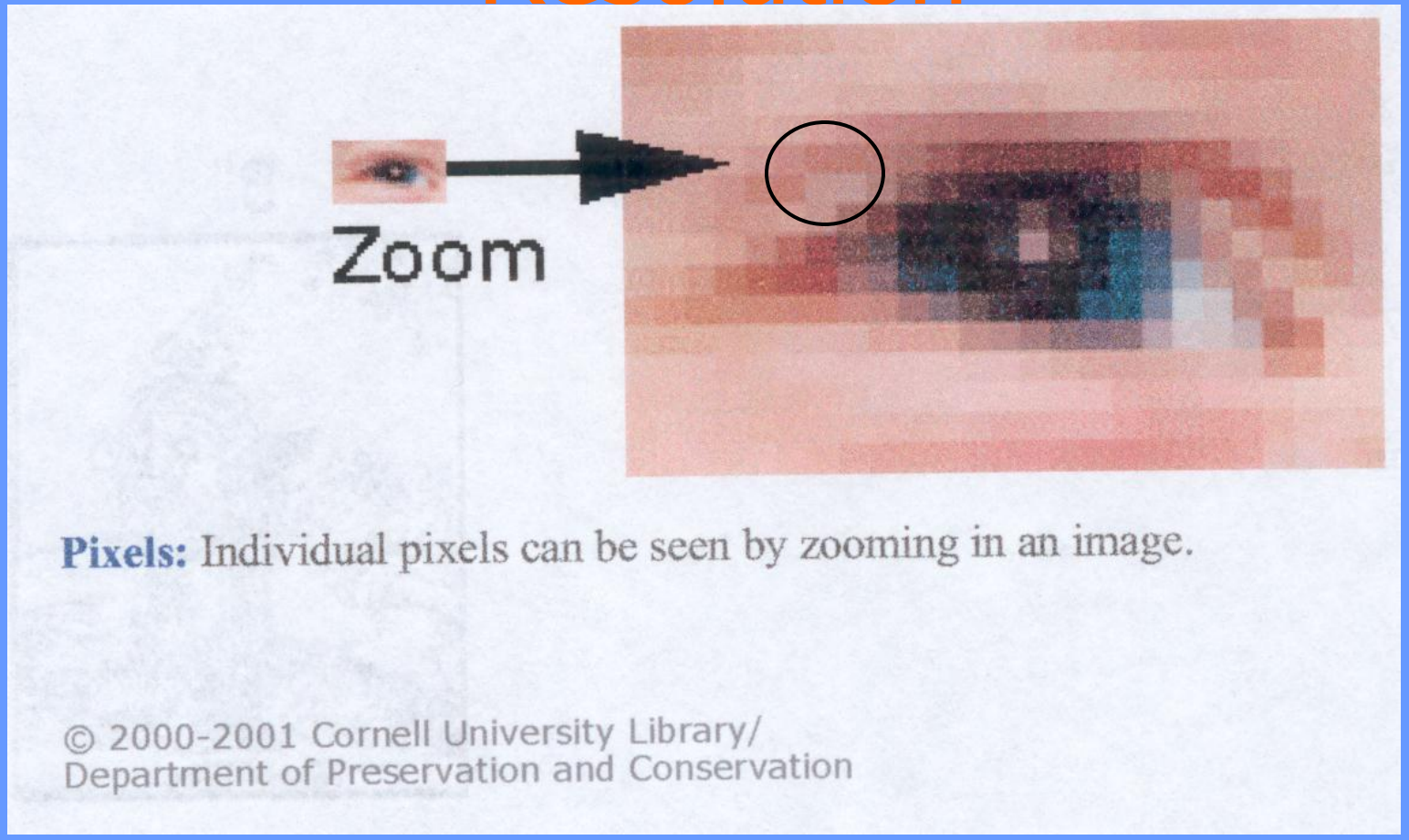
Pixel dimensions



An 8" x 10" document that is scanned at 300 dpi has the pixel dimensions of 2,400 pixels (8" x 300 dpi) by 3,000 pixels (10" x 300 dpi).

- Pixel dimensions are the horizontal and vertical measurements of an image expressed in pixels. The pixel dimensions may be determined by multiplying the width and the height by the **definition of the scanning** expressed in **dpi** : dots per inch = an 8" x 10" document scanned at 300 dpi has the pixel dimensions of 2.400 pixels (8" x 300 dpi) by 3.000 pixels (10" x 300 dpi)
- A digital camera or a computer **display** will also have pixel dimensions expressed as the number of pixels horizontally and vertically that define its **resolution** : 1024 x 768

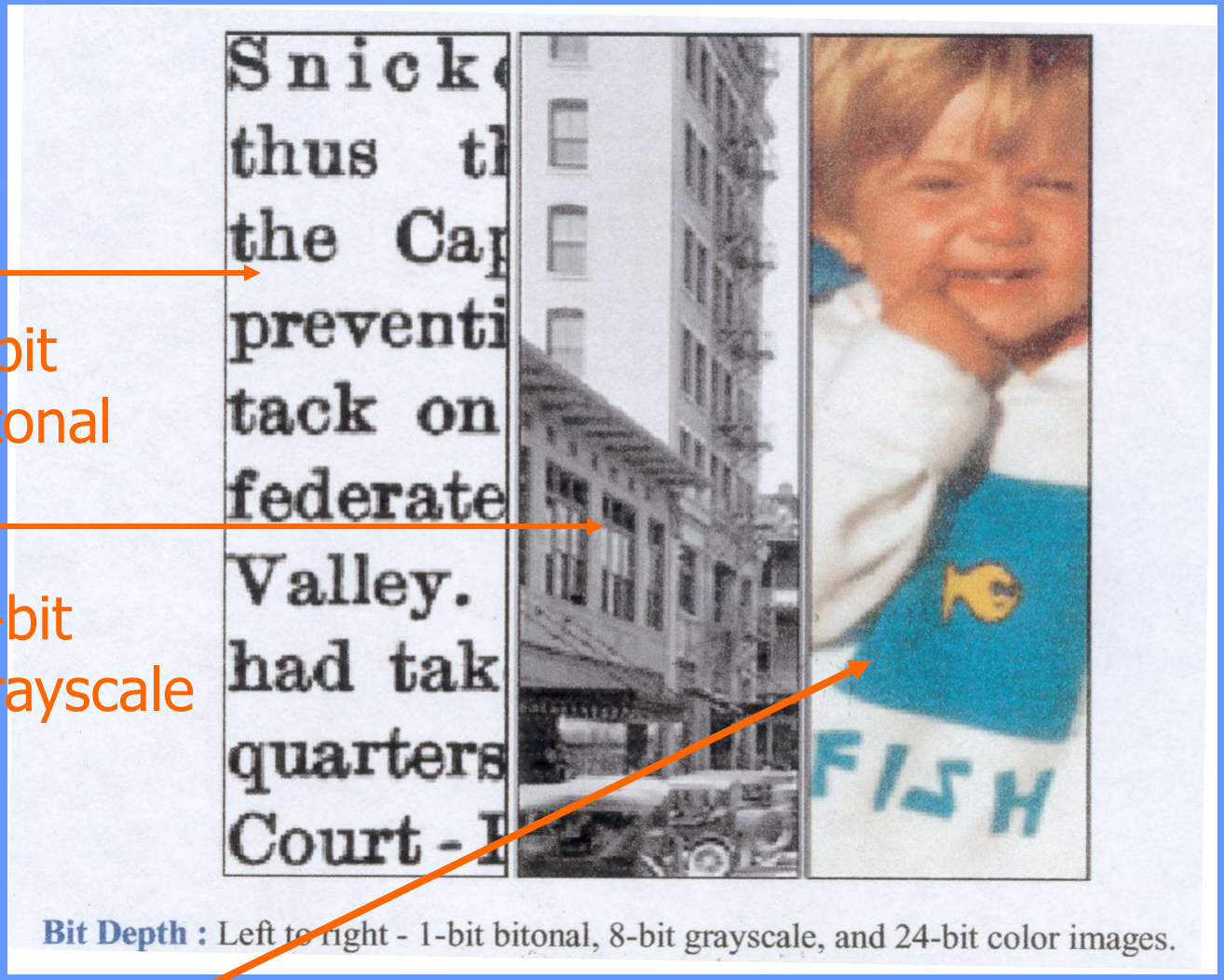
Resolution



Pixels: Individual pixels can be seen by zooming in an image.

- Resolution is the ability to distinguish fine **spatial detail**. The spatial frequency at which a digital image is sampled (**sampling frequency**) is often a good indicator of resolution.
- **Dpi** or **ppi** (pixels per inch) are synonymous terms to express resolution

Bit depth



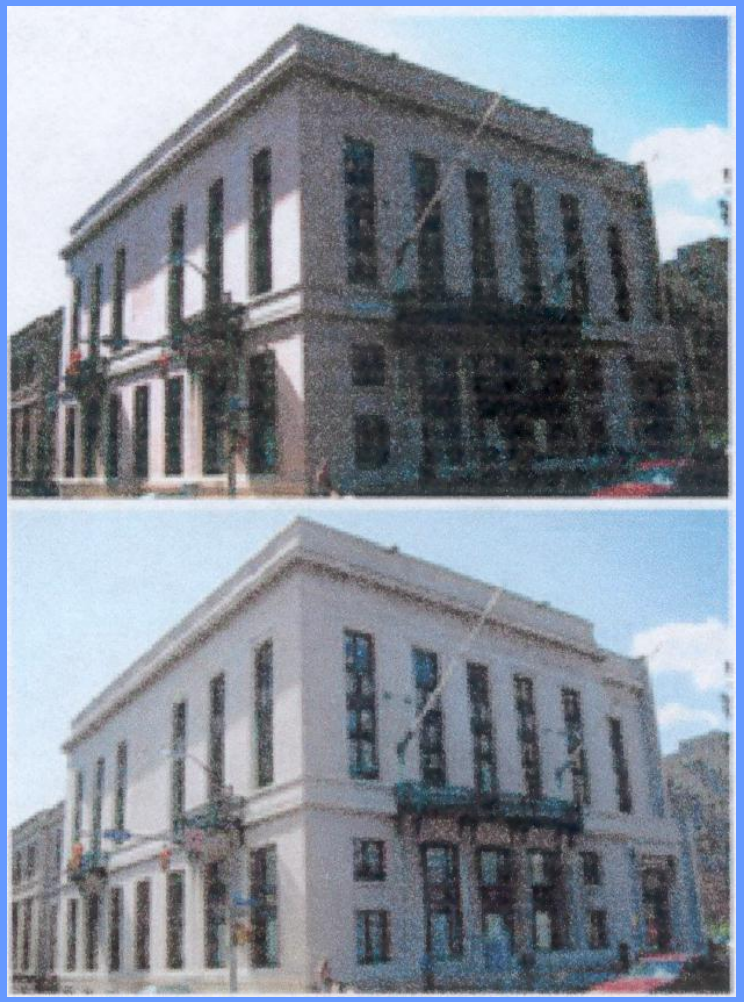
A 24-bit image offers 16,7 millions (2^{24}) color values

Bit depth

- Bit depth is determined by the **number of bits** used to define each pixel.
- The greater the bit depth the greater the **number of tones** (grayscale or color) that can be represented

- A color image is typically represented by a bit depth ranging from 8 to 24 or higher. With a 24-bit image the bits are often divided into 3 groups : 8 for red, 8 for green and 8 for blue (RGB ???)

Dynamic range



- Compare top image with limited dynamic range

  with bottom image : lack of detail in shadows and highlights

- Dynamic range is the range of tonal difference between the lightest light and darkest dark of an image.

- Dynamic range also describes a digital system's ability to reproduce tonal information.

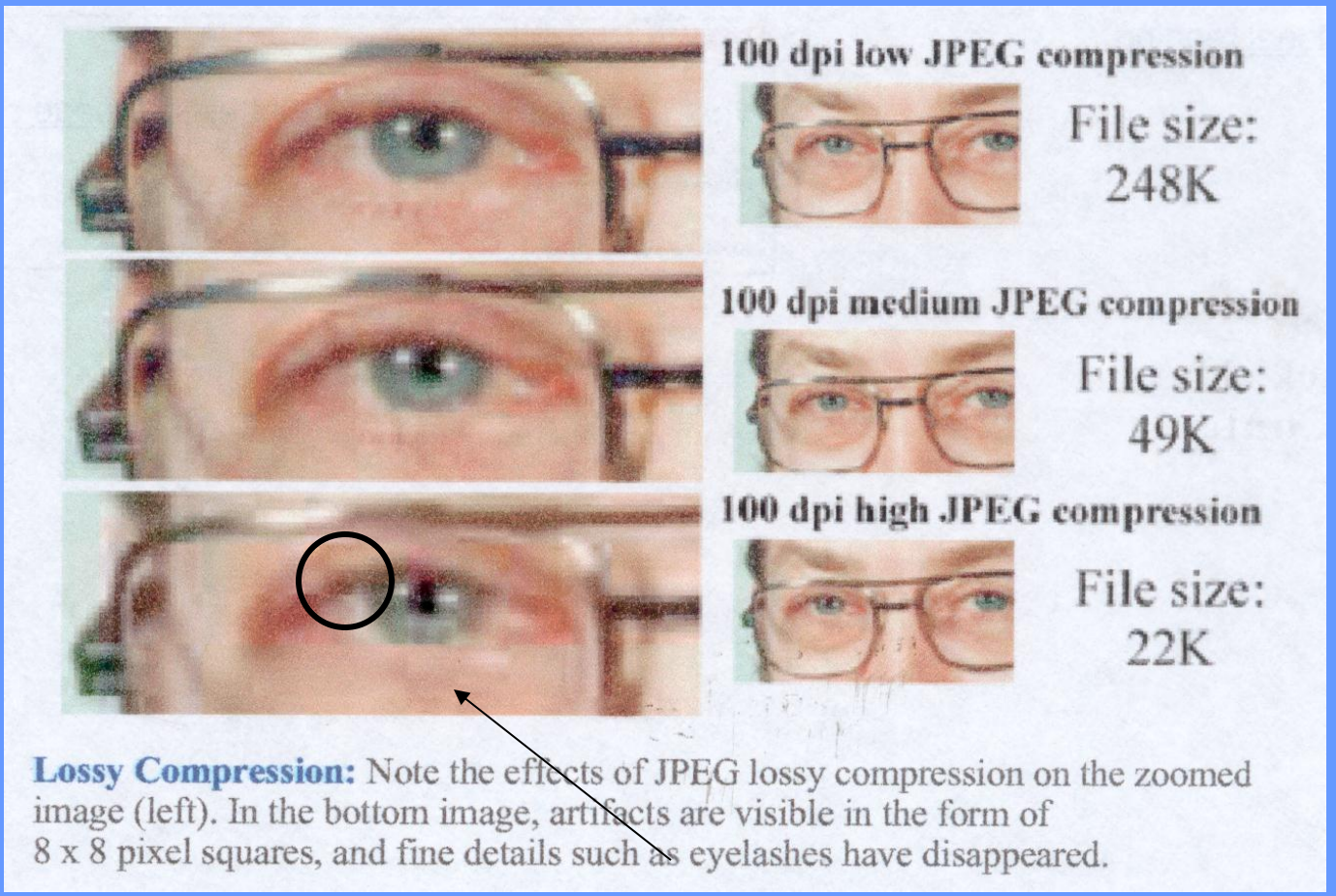
File size

- Image file size is represented in **bytes (octets)** which are made of 8 bits

- File size = (height x width x bit depth x dpi^2)/8
- or = (pixel dimensions x bit depth)/8

- Because digital images result in very larges files, the number of bytes is usually represented in increments of 2^{10} (1024) or more
- 1 Kilobyte (KB) = 1.024 bytes
- 1 Megabyte (MB) = 1.024 KB
- 1 Gigabyte (GB) = 1.024 MB
- 1 Terabyte (TB) = 1.024 GB

Compression



Lossy Compression: Note the effects of JPEG lossy compression on the zoomed image (left). In the bottom image, artifacts are visible in the form of 8 x 8 pixel squares, and fine details such as eyelashes have disappeared.

- Compression is used to reduce image file size for storage, processing and transmission.

Common Image File Formats

- File formats consist of both the **bits** that comprise the image and **header** information on how to read and interpret the file. They vary in terms of resolution, bit depth, color range, capacity of compression and metadata
- TIFF (Tagged Image File Format) : .tif, .tiff, uncompressed, lossless
- GIF 89a (Graphics Interchange Format) : .gif, lossless
- JPEG (Joint Photographic Expert Group) : .jpeg, .jpg, lossy
- PNG (Portable Network Graphics) : .png, lossless, may replace GIF
- PDF (Portable Document Format) : .pdf, uncompressed, lossless

From basics of digital to digital moving images and associated sounds

Now that we are more familiar with some of the key concepts we shall try to go further in the understanding of digital processes for moving images and associated sounds

Digital terminology applied to moving images and associated sound

- Analogue : common term used in comparison with digital
  - an analogue electric signal represents continuous variations of a physical value
  - a wave whose amplitude varies with time
  - variations of acoustic pressures transformed in current variations to form the audio signal
  - variations of light intensity captured by a lens and converted into a video electric signal by CCD (CCD : Charged Couple Device) of the camera
- Digital : representation of information data or physical values by the means of numbers (0, 1)
  - sequences of symbols
  - discontinuous : from one to another in sudden transition
  - 1 and 0 stand for high or low levels of the corresponding electric signal (cf the grid of dots or pixels with tonal values)

Digital terminology applied to moving images and associated sound

- Digital stands for
  - film images converted into digital files through a film scanner
  - computer data
  - video
- Bit : binary digit (element of a binary chain)
  - digitalization of a signal = conversion of current (volts) or of amplitudes of each sample into a binary number (0 and 1) = bit
  - 8 bits = 1 byte (octet)
- 2K, 4K : K for Kilo (1000)
  - 2K = refers to the notion of definition in digital cinema, allows invisible special effects before return to film
  - 4K = better definition
- Telecinemas-scanners in 2K (time necessary for scan is greatly reduced : + or - 6 seconds/frame, depending on the technology and manufacture)

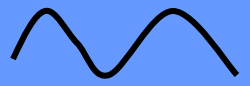
Basics of digital in relation with moving images and associated sound

- Digital processes are now used in the restoration of some defects that cannot be treated photochemically
- These treatments are still very expensives and out of reach of many film archives. But it is forseen as a possible future for film archives
- Digital processing of film follows 3 steps :
  - scanning of film to convert frames into data files
  - treatments (scratches and fungus removal, color fading correction, etc.) are operated on a workstation with specific softwares derived from graphic solutions
  - shooting on film of restored files
- Scan is still slow even though it has improved much (from 18 sec/frame to 6 to 25 frames per sec
- Shooting back on film : from 12 sec/frame to 3-5 sec/frame

Basics of digital in relation with moving images and associated sound

- Softwares used in the digital treatment of images sometimes produce unexpected (unwanted) effects : arms and heads of actors disappear in movements and in panoramics
- It is necessary for archivists to determine the extent of the processes and to assist the operator

Basics of digital in relation with associated sound

- **ANALOGICAL AND DIGITAL SOUND**
  - Sound is represented by a signal whose value varies according to time in a continuous way
  - An example is that of a **sinusoidal** signal (whistle or tuned note) 
  - We use to call it an **analogical** signal. Its shape is rather simple. This signal may be altered in many ways during :
    - the process of producing and recording sound (microphones)
    - the transfer of the recorded sound onto another tape (35 mm magnetic stock for example)
    - the exhibition in cinemas (amplifiers and loud speakers).
- The analogical signal is sensitive to interferences. It can be altered by the transmitting devices both in amplitude and in phase, and therefore acquire distortions.
- Each time we process a sound (to rerecord it for example) we most often reduce the quality of it in comparison to that of the original.

Basics of digital in relation with associated sound

- PCM : Pulsion Coded Modulations (PCM), i.e. the digitalization of a signal

  The **digital** signal is represented by sequences of binary symbols : 0 and 1, corresponding to : 0 = nothing, 1 = electric impulse.

  That signal is much less sensitive to defects induced by transmission systems.
- The **digital treatment of a sound** consists in quantifying this sound in binary impulses then deciding and determining the new shapes to give to the sound.

Basics of digital in relation with associated sound

- With **analogue correcting processes** sound is treated as a whole, not by samples. All the sounds receive the same amount of treatment as the entire process
- This is why a noise modulation or an analogue processed induction will also alter part of good quality sound that we would prefer to leave unaffected. Nowadays there exist many specially developed softwares that are more or less well adapted to digital sound treatments
- Great expectations from new approaches such as that demonstrated by Manno Sándor

A new digital world for archives ?

- Images treatments
- Sound restoration
- Digital video
- Scanners and digital telecinemas
- Digital media for storage
- Obsolescence
- Metadata

A new digital world for archives ?

Heard over the years:

"BetacamSP is the answer to all our prayers."
"Digital Betacam is the answer to all our prayers."
"DVC is the answer to all our prayers."
"DVCPro is the answer to all our prayers."
"CD-ROM is the answer to all our prayers."
"DVD is the answer to all our prayers."
"DLT is the anwer to all our prayers."

Is a pattern emerging?

Besides, just think, we will shortly be able to store 40 terrabytes on a Palmpilot.

A new digital world for archives ?

- on a practical level a Terabyte will store 10 hours more or less

  10 Terabytes will store 100 hours
  100 Terabytes will store 1,000 hours
  1,000 Terabytes will store 10,000 hours
  10,000 Terabytes will store 100,000 hours
  100,000 Terabytes will store 1,000,000 hours

- 1024 terabytes is a petabyte (PB) and
  1024 petabytes is an exabyte (no relation to Exabyte tapes - they only hold 5 gigabytes {GB}).
- several hundred petabytes or up to half an exabyte to store everything at ScreenSound Australia in digital form.

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