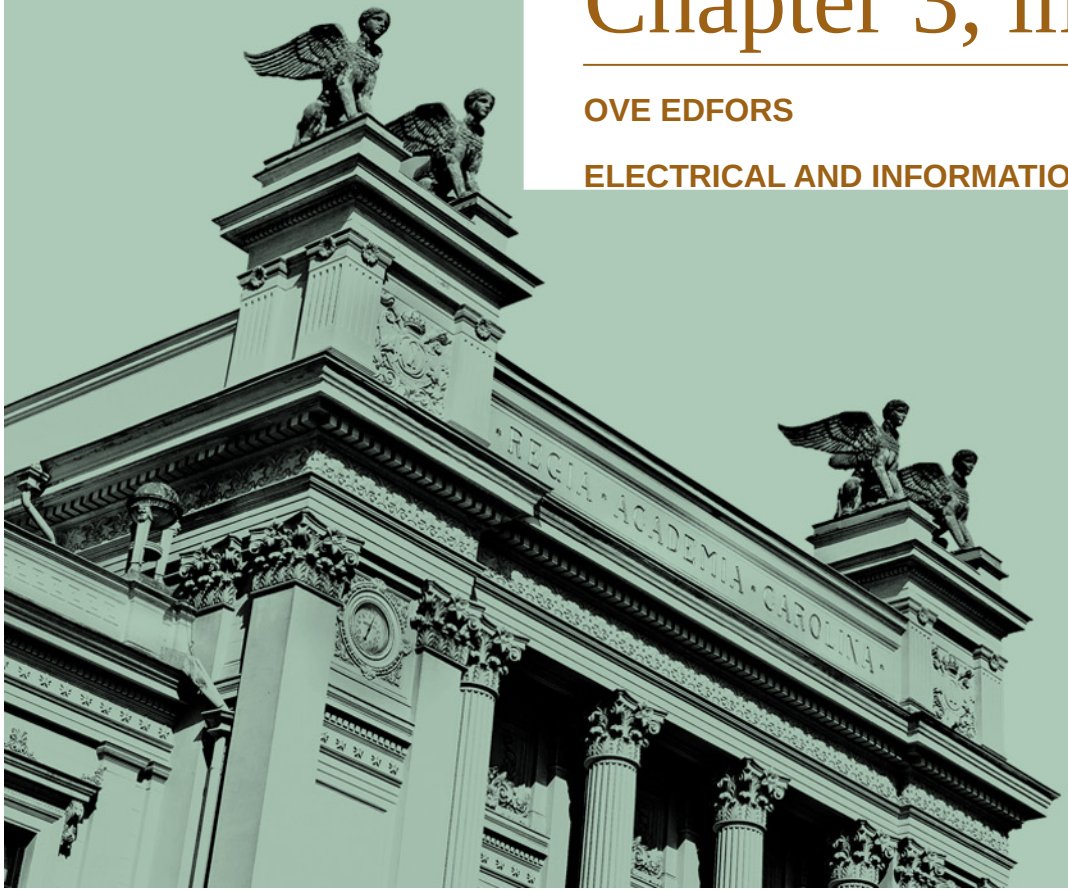
Information Transmission Chapter 3, image and video

OVE EDFORS

ELECTRICAL AND INFORMATION TECHNOLOGY



Learning outcomes

Understanding

- raster image formats and what determines quality,
- video formats and what determines quality, and
- the basics of image and video compression.

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Images

- An image is a two-dimensional array of light values.
- Make it 1D by scanning
- Smallest element of an image is called a pixel.
- Number of pixels per cm/inch gives the resolution of the image.

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Resolution

- Resolution of, e.g., a printer is in dots per inch (DPI). Each dot is represented by a bit.
  - 300 DPI – 12 dots/mm

- When the dots have different levels of grey, the image is said to be of gray scale. Usually, 256 gray levels are used, so that each pixel is represented by 8-bits

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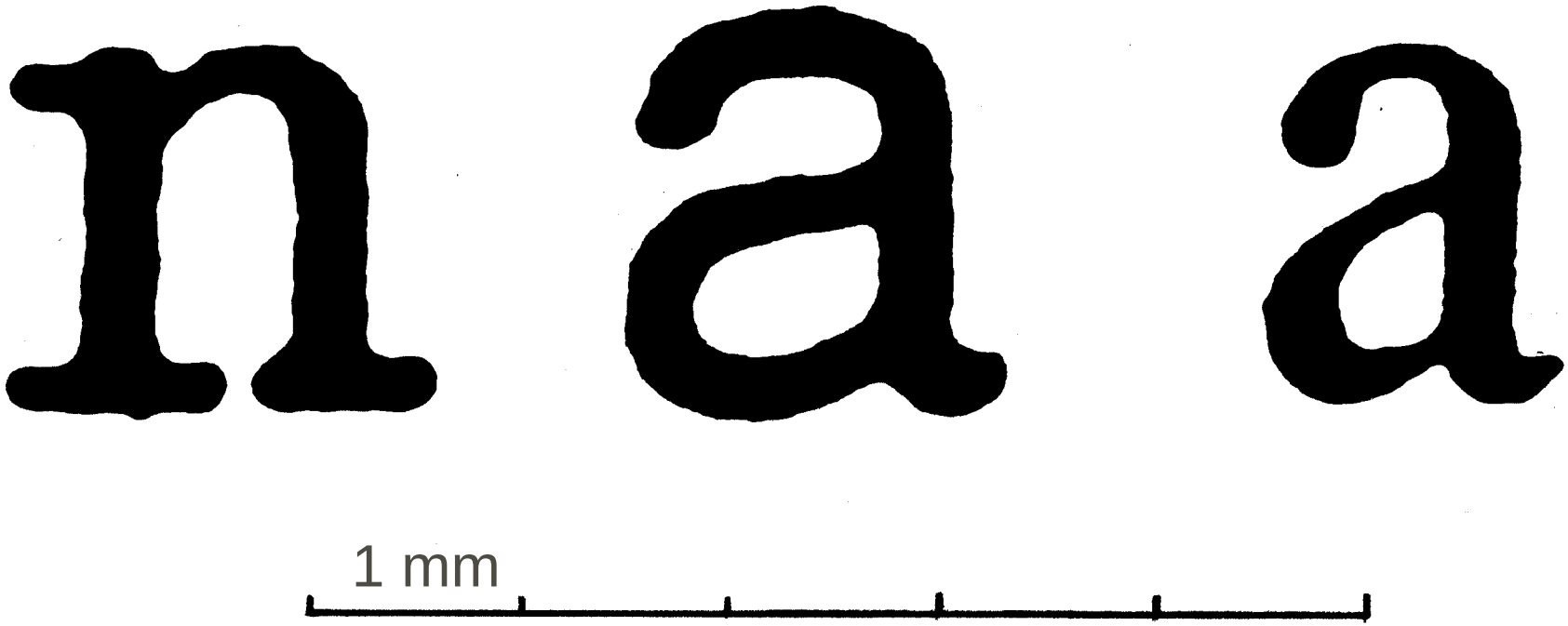
Example, 90, 300, 600 DPI



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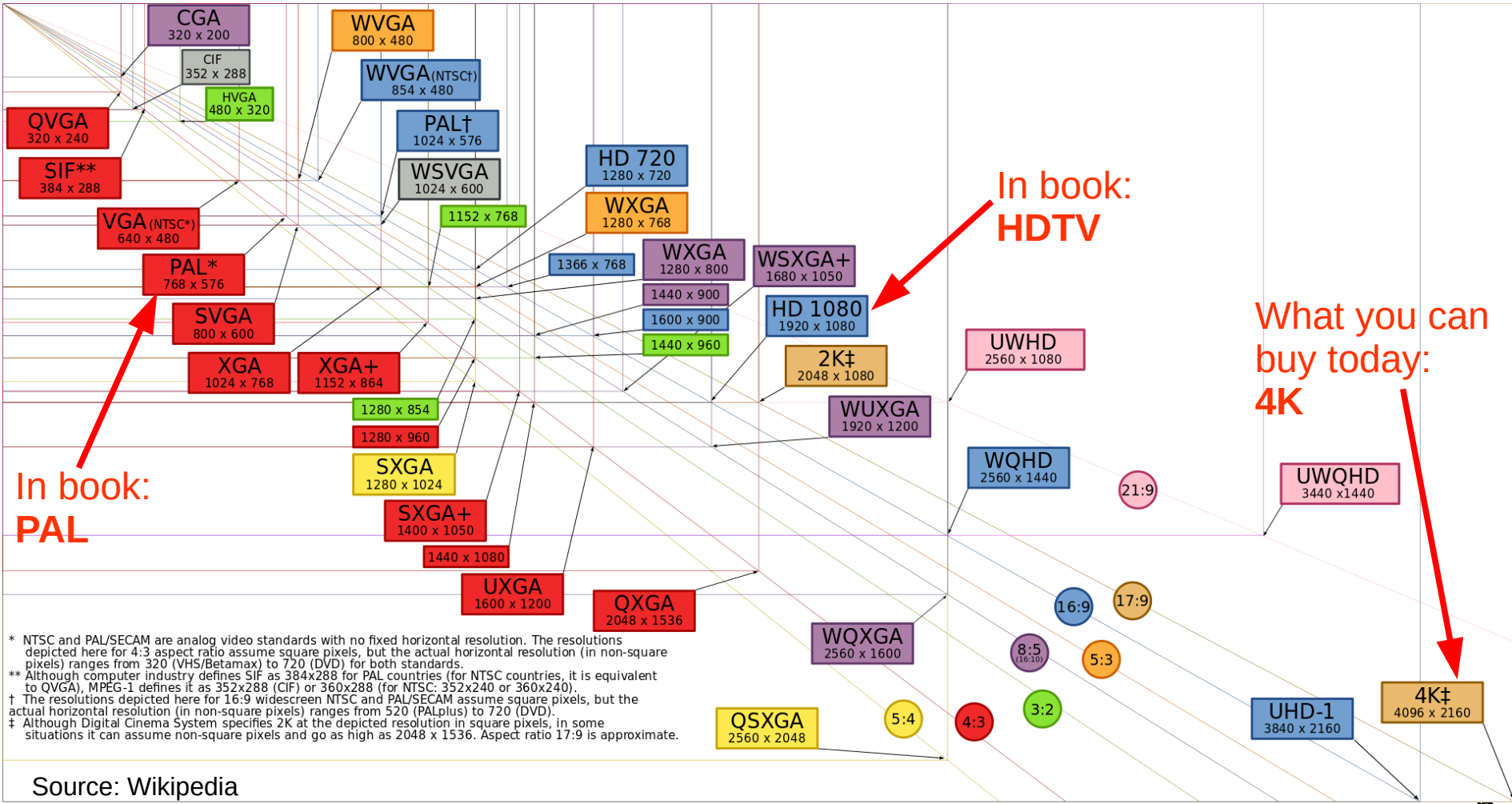
Display resolutions



* NTSC and PAL/SECAM are analog video standards with no fixed horizontal resolution. The resolutions depicted here for 4:3 aspect ratio assume square pixels, but the actual horizontal resolution (in non-square pixels) ranges from 320 (VHS/Betamax) to 720 (DVD) for both standards.
** Although computer industry defines SIF as 384x288 for PAL countries (for NTSC countries, it is equivalent to QVGA), MPEG-1 defines it as 352x288 (CIF) or 360x288 (for NTSC: 352x240 or 360x240).
† The resolutions depicted here for 16:9 widescreen NTSC and PAL/SECAM assume square pixels, but the actual horizontal resolution (in non-square pixels) ranges from 520 (PALplus) to 720 (DVD).
‡ Although Digital Cinema System specifies 2K at the depicted resolution in square pixels, in some situations it can assume non-square pixels and go as high as 2048 x 1536. Aspect ratio 17:9 is approximate.

Source: Wikipedia

Images

- Representing color images requires specifying the intensities Red, Green and Blue (RGB) colors.
- Digital images require huge memory for storage.
- Sophisticated image compression schemes like JPEG are employed to reduce the size of images.
- These schemes employ the properties of images and the behavior or response of human eye to reduce redundancy.

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Let's zoom in!


Doesn't look as nice in close-up.

Image formats

- Vector formats (e.g. SVG, EPS)
  - Specify where lines should be drawn
- Raster format (e.g. TIFF/JPEG/PNG/GIF/BMP)
  - Specify each pixel value (RGB)
  - May use different levels of compression

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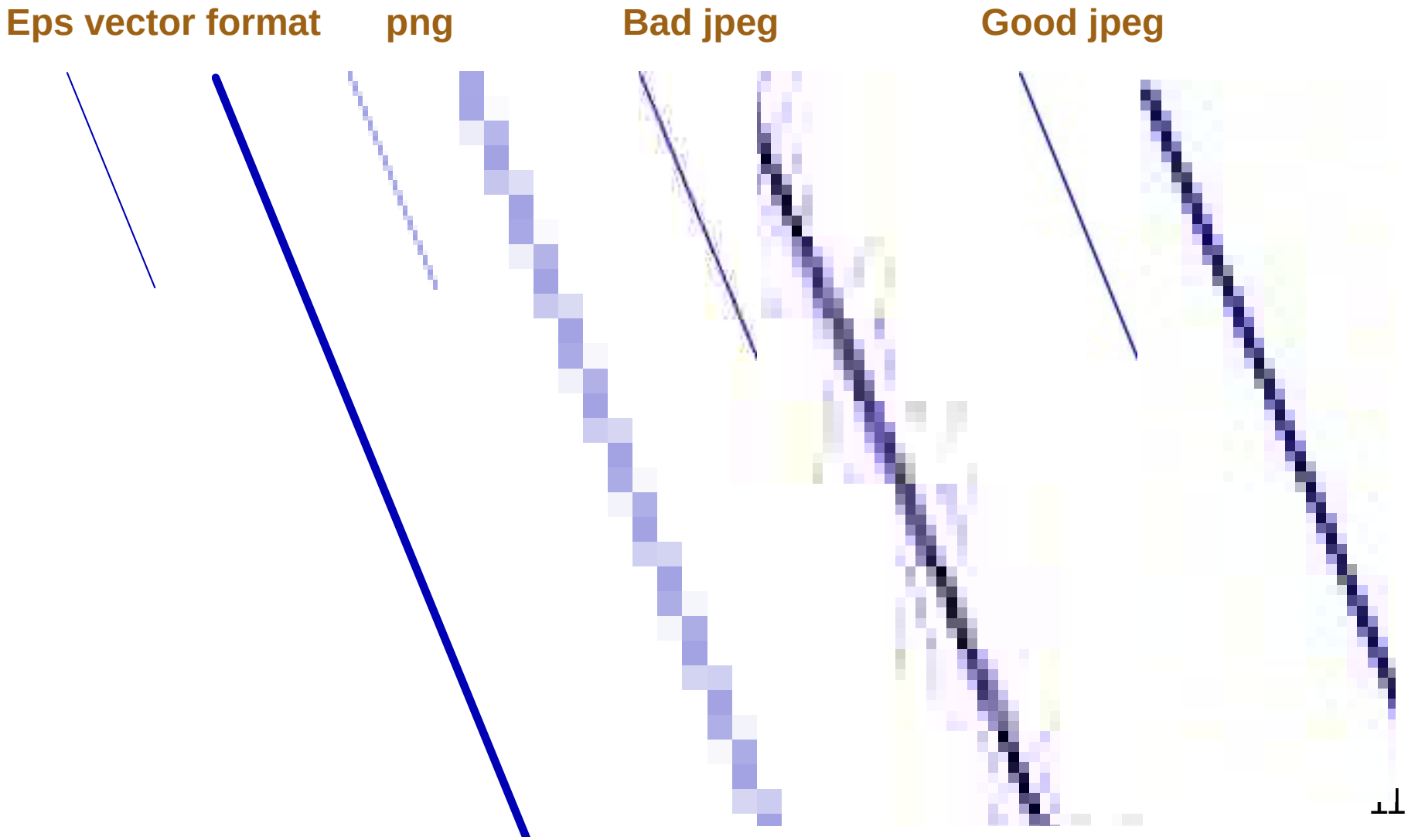
Picture formats (original+5x magn.)



JPEG encoding

- The representation of the colors is converted from RGB to $Y'C_BC_R$, consisting of one **luma component** (Y') for brightness, and two **chroma components**, (C_B and C_R), for color.
- The resolution of the chroma data is reduced. This reflects the fact that the eye is less sensitive to fine color details than to fine brightness details.
- The image is split into blocks where each of the Y, C_B, and C_R data undergoes the Discrete Cosine Transform, similar to a Fourier transform.

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JPEG encoding

- The amplitudes of the frequency components are quantized. Human vision is much more sensitive to small variations in color or brightness over large areas than to the strength of high-frequency brightness variations.
- The magnitudes of the high-frequency components are stored with a lower accuracy than the low-frequency components. If an excessively low quality setting is used, the high-frequency components are discarded altogether.
- The resulting data for all blocks is further compressed with a lossless algorithm.

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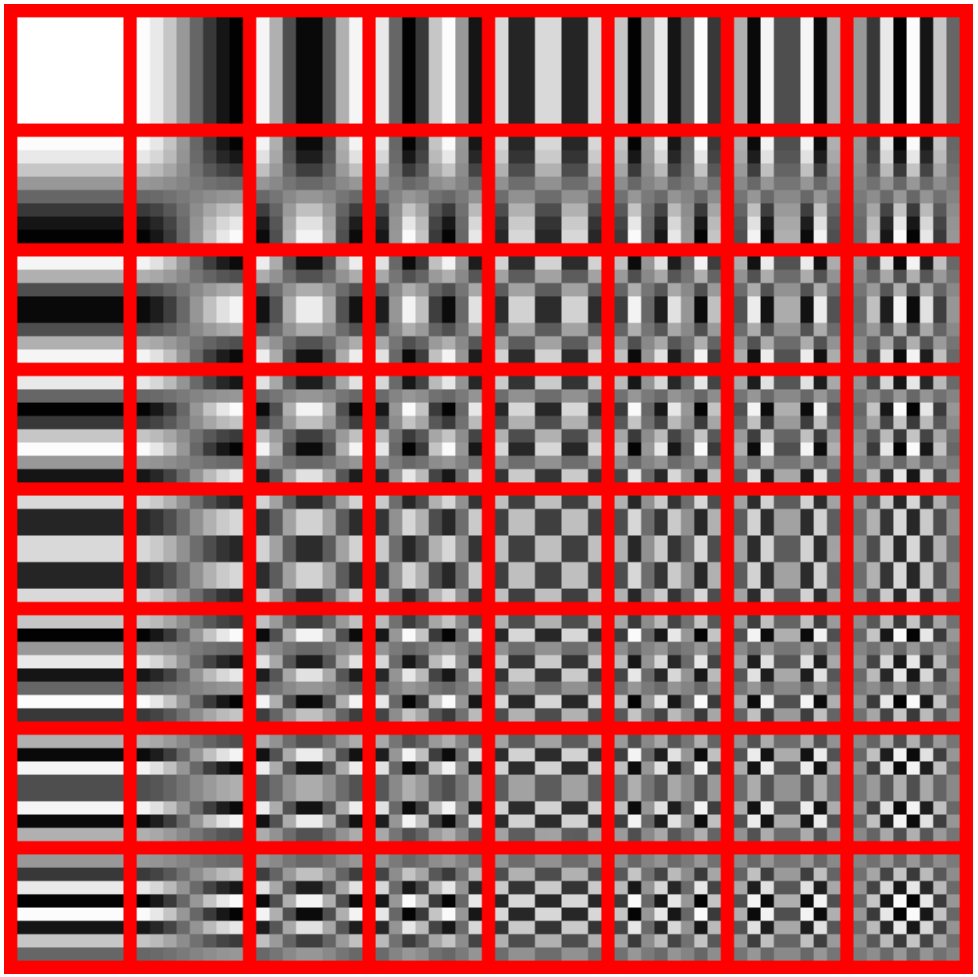
Fourier (cosine) transform of an image?

- Represent the image by its frequency components
- Linear combination of the squares here



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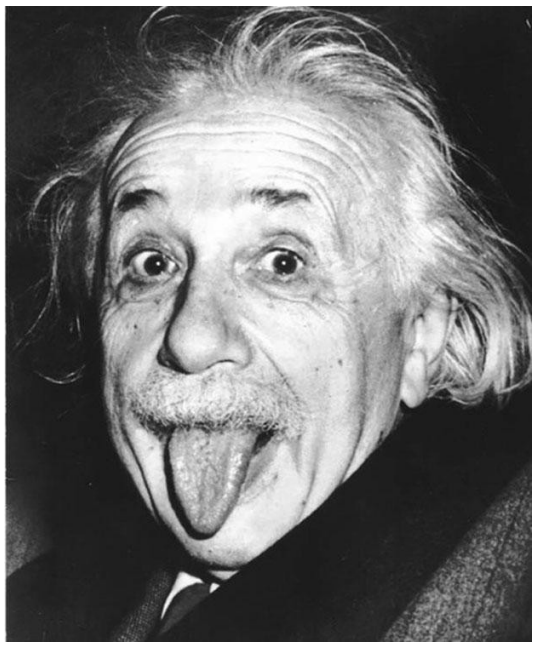
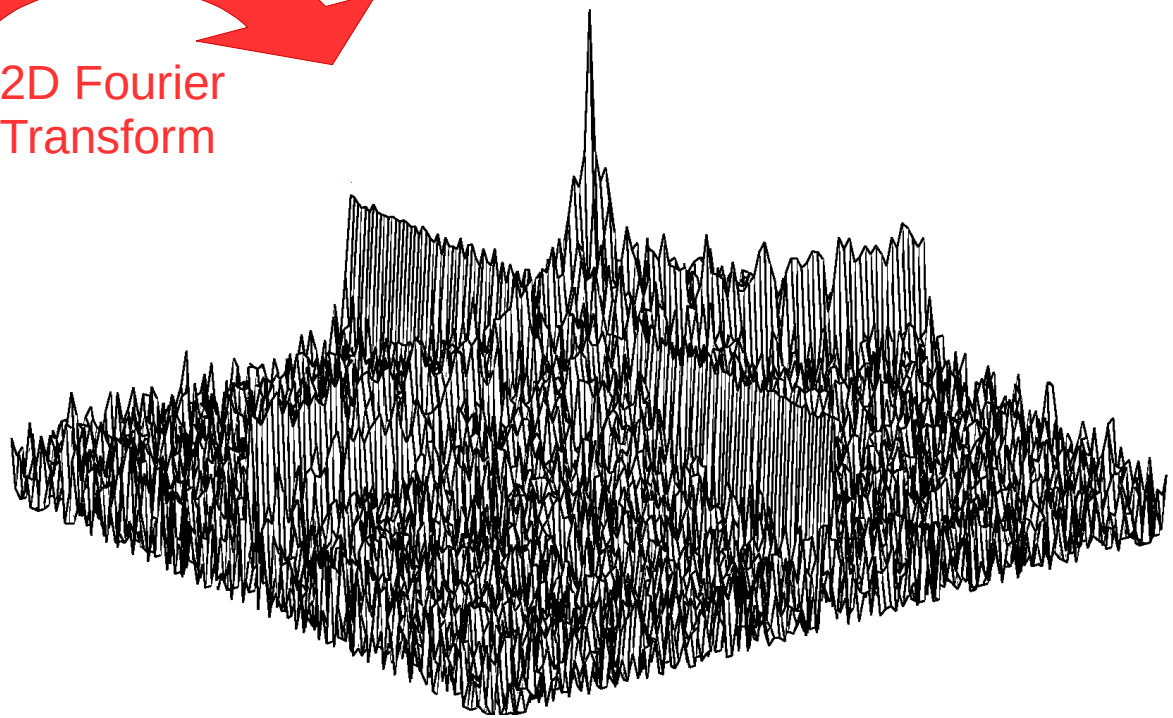
Einstein in the frequency domain



2D Fourier Transform



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Video

- Video is a continuously changing image or a sequence of still images to give an impression of motion.
- Human eye suffers (or benefits?) from persistence of vision.
- An image persists for about 60ms; if next image comes before this time, it appears to be continuous.
- Also eye averages out the noise in successive images thus boosting the effective SNR.
- These features are used to advantage in TV/video transmission.

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Rasters in video

- To generate a TV signal, the TV screen or raster is scanned at a very high rate.
- In the PAL system, a frame rate of 25 frames/second is used to scan the raster. This yields a maximum bandwidth of 6.5 MHz for the TV signal, a bandwidth of 1-2 MHz provides satisfactory picture quality.
- An SNR of 20 dB is sufficient for the video signal.
- Digital video signals have very high bit rates 60 Mbps. Hence video compression algorithms like MPEG are widely employed that bring down to 2-5 Mbps

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HDTV

- High Definition TV: Increasing the number of scan lines and increasing the analog bandwidth (50 MHz), thereby increasing the resolution.
- Sophisticated video compression schemes bring down the bit rates to 10-20 Mbps. This allows transmission of HDTV signal in the same frequency channel used by analog TV (6-7 MHz)
- MPEG-2 Video compression standard includes the HDTV apart from standard TV.

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Video compression

- The sequence of images contains spatial and temporal redundancy that video compression algorithms attempt to eliminate or code in a smaller size.
- Only small differences between successive images.
  - Use differential encoding: transfer/store differences
- Objects move or change
  - shift, rotate, lighten, or darken

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History of video compression standards

Year	Standard	Publisher	Popular Implementations
1984	H.120	ITU-T	
1988	H.261	ITU-T	Videoconferencing, Videotelephony
1993	MPEG-1 Part 2	ISO, IEC	Video-CD
1995	**H.262/MPEG-2** Part 2	ISO, IEC, ITU-T	DVD Video, Blu-ray, Digital Video Broadcasting, SVCD
1996	H.263	ITU-T	Videoconferencing, Videotelephony, Video on Mobile Phones (3GP)
1999	MPEG-4 Part 2	ISO, IEC	Video on Internet (DivX, Xvid ...)
2003	**H.264/MPEG-4** AVC	Sony, Panasonic, ISO, Samsung, IEC, ITU-T	Blu-ray, HD DVD Digital Video Broadcasting, iPod Video, Apple TV,
2009	VC-2 (Dirac)	SMPTE	Video on Internet, HDTV broadcast, UHDTV
2013	H.265	ISO, IEC, ITU-T	High Efficiency Video Coding

Source: Wikipedia

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DVB-T2 (Digital Video Broadcasting –T2)

Digital Modulation	Lines	Frame rate	Data rate	CH. B/W (MHz)
COFDM (4/16/64/ 256 QAM)	1080	up to 50p	Up to 50.34 Mbit/s	1.7, 5, 6, 7, 8, or 10

Video Coding	Audio Coding	Interactive TV	Digital subchannels	Single-Frequency Network
H.264, H.262	MPEG-1 Layer II, HE-AAC	yes	Yes	Yes

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SUMMARY

- (Raster) Image:
  - A 2D signal or array of color/light values
  - Smallest element called a pixel
  - Resolution often given in pixels/inch (PPI) or dots/inch (DPI)
  - Three component colors (typically RED, GREEN, BLUE) are required for color images.
- Video:
  - Sequence of images (frames)
  - Frame rate based on human persistence of vision
- Compression methods:
  - Based on properties of images and human visual system
  - Can reduce storage size considerably

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