Multimedia Systems - Video

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Colour

- Colour is a visual feature which is immediately perceived
- Salient chromatic properties are captured
- Colour can add great value to an image
- Presence and distributions of colours induce sensations and conveys meanings in the observer according to specific rules
- Representing colour on digital images and reproducing accurately on output devices are not at all straightforward
- Distances in colour space should correspond to human perceptual distance

Human Visual Perception

- Mixing three primary colours in varying proportions, the perception of different colours can be created
- Human eye build up of
  - Cones to perceive colour
  - By exciting retina using different intensities of the three primary colours, the same colour may be perceived by the brain even if its unique wavelength is not present.

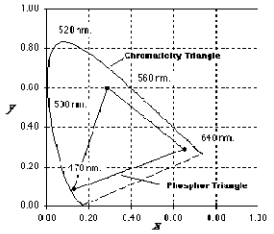
Human Information processing

- Identical colour combinations can cause different colour sensation under different conditions
- Likewise two different colour can be perceived identical …
- the human eye & brain
  - Interpolation
  - Pictures and events that can still be identified as separate
  - Colour interaction in the brain
- Adaptation
  - General-brightness adaptation
  - Lateral adaptation
  - Chromatic adaptation

Colour Space

- To deal with colour we need to quantify it in some way
  - gives us the notion of colour space or domain
- Hierarchy of colour sets
  - Perceivable by human beings
  - Displayed on a monitor screen
  - Calculated and stored in a frame memory

CIE Chromaticity Diagram



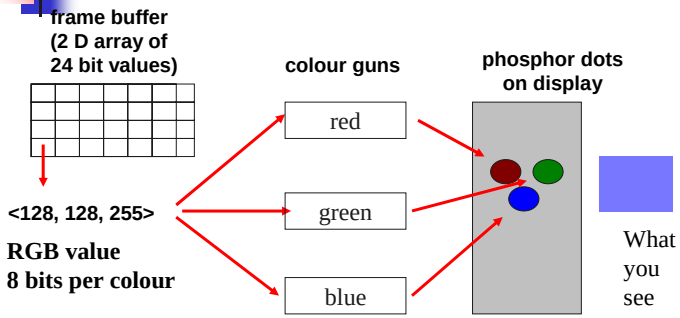
Representation of Colour Stimuli

- Points in three dimensional space
- Calorimetric models
  - CIE Chromaticity diagram
- Physiologically inspired models
  - CIE XYZ, RGB
- Psychological models
  - HSV,
- Hardware-oriented models
  - RGB, CMY, YIQ
- User-oriented models
  - HLS, HSV, HSB

Video Technology: representing colour

- monochrome
  - bilevel
    - one bit/pixel: 0 = black, 1 = white
  - grey-scale
    - e.g., 8 bits/pixel = 256 intensities
- colour
  - value for each colour gun
  - no of bits gives colour range
    - e.g., 24 bits = 8 bits for red, 8 bits for green, 8 bits for blue
    - colour depth

Video Technology:
generating a colour

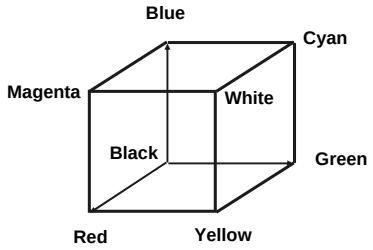


Video Technology:
Colour Models: RGB

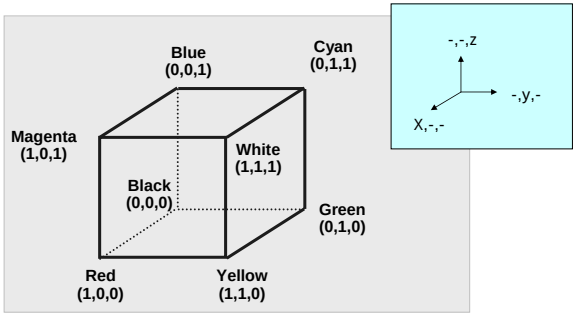
- RGB = Red Green Blue
- directly modelled in device (i.e., corresponds to colour guns in display)
- easy to implement

- not based on visual (perceived) colours
- not perceptually uniform

Video Technology:
Colour Models: RGB Colour Space



Video Technology:
Colour Models: RGB Colour Space



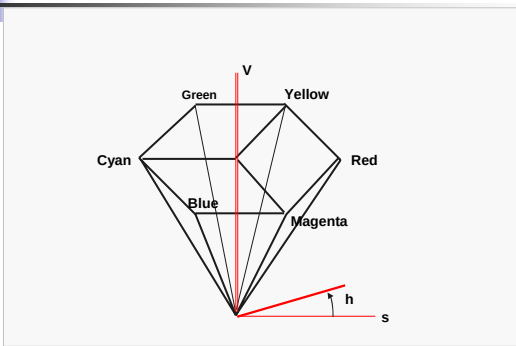
Video Technology:
Colour Models: RGB

- Colour is labeled as a relative weights of three primary colours, in an additive system using the primaries Red, Green, Blue
- It is perceptually non-linear space
  - Equal distances in the space do not necessarily correspond to perceptually equal sensation
- Non-linear relationship between RGB values & the intensity produced in each phosphor dot, low intensity values produce small changes in response to screen
- It is not a good colour description system

Video Technology:
Colour Models: HSV

- HSV = hue, saturation, value (intensity)
- "painter's model"
- better model for representing colours as we see them ("I want a bright highly saturated apple green.")
- desaturation = adding white
- can be converted to/from RGB
- like RGB, axes not perceptually uniform
- variant: HLS (hue, lightness, saturation)

Video Technology:
Colour Models: HSV Colour Space



Video Technology:
Colour Models: HSV

- Non-linear transformation of RGB cube
- Hue : quality by which we distinguish one family from others
- Chroma: quality by which we distinguish a strong colour from weak ones
- Value: It is that quality by which we distinguish a light colour from a dark one
- H corresponds to selecting a colour; S corresponds to selecting the amount of white; selecting V corresponds to adding black
- Perceptually non-linear
  - Perceptual in the sense that we are using attributes that we normally think of
  - Attributes are not independent
- variant: HLS (hue, lightness, saturation)

Video Technology:
Colour Models: YUV

- colour model used for TV signal transmission
- Y represents luminance (intensity of monochrome signal)
- U,V carry separate colour information (colour difference values)
- Y = 0.2125R + 0.7154G + 0.0721B
- U = B-Y, V = R-Y
- typically, Y contributes most to signal bandwidth

Video Technology:
CIE Colour Specification System

- Commission Internationale d'Éclairage
- colour labelling system
- "XYZ" space
- international standard (1931)
- based on colour matching functions determined by experiments with human subjects
- gives uniform colour spaces
- needs transformation into one of the other models

Video Technology:
Colour Models: CMYK

- CMYK = cyan, magenta, yellow, black
- "printer's model"
- a subtractive model
- set of practically available CMYK colours ("process colours") are not equivalent to RGB set

Pushing the hardware

- Consumers expectations are based on broadcast television
- Consumer equipment plays back at reduced frame rate resulting in jittery- dropped frames
- In order to accommodate low-end PCs considerable compromises over quality must be made

Persistence of vision

- If a sequence of still images is presented to our eyes at sufficiently high rate (frame rate~40 fps), we experience a continuous visual sensation rather than perceiving individual images
  - A lag in the eye's response to visual stimuli which results in after images
- If the consecutive images only differ by a small amount, any changes from one to next will be perceived as movement of elements within images
- Film projector displays an image twice (24 fps becomes 48 fps)

Human Perception

- What frame rate perceived as smooth?
  - No identification of single frames if refresh frequency is high enough
  - Perception of 16 frames/s as continuous sequence
  - Depends on material
- More sensitive to low frequencies
- More sensitive to changes in luminance and blue-orange axis
- Vision emphasizes edge detection

Video Sequence

- Consists of number of frames
  - Images produced by digitising time-varying signal generated by the sensors in a camera
  - Bit-mapped images
- Camera
  - Circuitry Inside a Camera
  - Purely digital signal (data stream) is fed into a computer via a high speed interface
    - IEEE 1394 (FireWire)
- Computer
  - Broadcast video is fed into a video capture card attached to the computer
  - Video capture card- analogue signal is converted into a digital form

Digitization: camera vs computer

- Advantage
  - Analogue signal transmitted on a cable get corrupted by noise
  - Noise will creep in if analogue data is stored on a magnetic tape
  - Camera is resistant to corruption by noise and interference
- disadvantage
  - User has no control over digitization
  - Most conform to an appropriate standard

Video Bit Rate Calculation

$$\frac{\text{width} * \text{height} * \text{depth} * \text{fps}}{\text{compression factor}} = \text{bits/sec}$$

- width ~ pixels (160, 320, 640, 720, 1280, 1920, …)
- height ~ pixels (120, 240, 480, 485, 720, 1080, …)
- depth ~ bits (1, 4, 8, 15, 16, 24, …)
- fps ~ frames per second (5, 15, 20, 24, 30, …)
- compression factor (1, 6, 24, …)

Examples

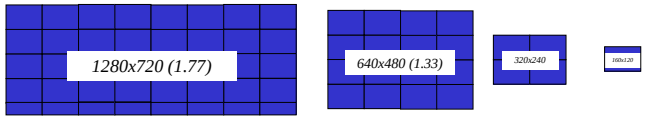
Width	Height	Depth	fps	Comp	Kb/sec	Notes
160	120	8	15	25	92	Basic Rate ISDN
160	120	16	20	20	307	
320	240	8	15	25	369	
320	240	16	24	24	1,229	MPEG1 (Primary Rate ISDN)
640	480	16	30	24	6,144	MPEG2
640	480	24	30	6	36,864	MJPEG
640	480	24	30	1	221,184	Uncompressed

Video Data Size

size of uncompressed video in gigabytes

	1920x1080	*1280x720*	*640x480*	*320x240*	*160x120*
1 sec	0.19	0.08	0.03	0.01	0.00
1 min	11.20	4.98	1.66	0.41	0.10
1 hour	671.85	298.60	99.53	24.88	6.22
1000 hours	671,846.40	298,598.40	99,532.80	24,883.20	6,220.80

image size of video



Effects of Compression

storage for 1 hour of compressed video in megabytes

	1920x1080	*1280x720*	*640x480*	*320x240*	*160x120*
1:1	671,846	298,598	99,533	24,883	6,221
3:1	223,949	99,533	33,178	8,294	2,074
6:1	111,974	49,766	16,589	4,147	1,037
25:1	26,874	11,944	3,981	995	249
100:1	6,718	2,986	995	249	62

3 bytes/pixel, 30 frames/sec

Video codecs

- Video capture boards
  - Digitization and compression
  - Decompression and digital to analogue transformation
  - Devices compressor/decompressor (codecs)
- Hardware codecs
  - Store them on a computer
  - Then play them back to an external video monitor (TV set) attached to the VCC
  - Most hardware codecs can not provide full motion video to monitor
  - We can not know our audience will have any hardware codec available
- Software codec
  - Program that performs the same operation