



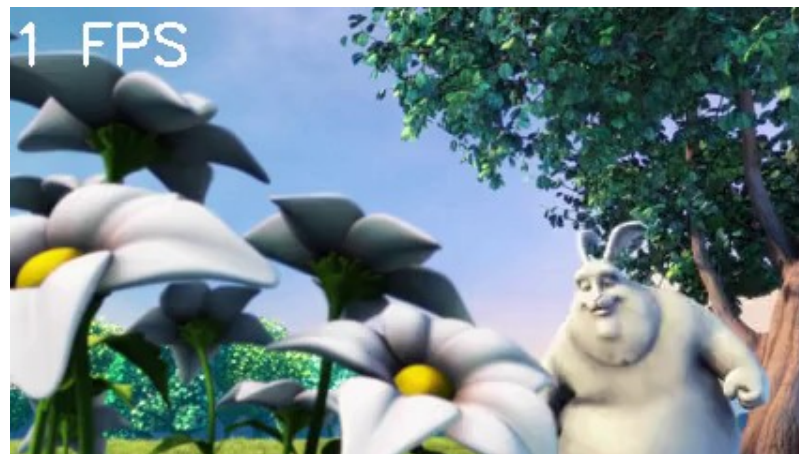
Video

# Video

- Videre (lat.) - to see
- Electronic medium for the recording, copying, playback, broadcasting, and display of moving visual (and audio) media
- Digital video – digital representation of video
  - Sequence of digital images
  - Compression algorithms
  - (+ digital sound)

# Temporal resolution

- Human perception system (eye+brain) can perceive about 10 - 12 images per second as separate images.
- Persistence of vision
  - Image „remains“ in cortex for 1/25s
  - Neuron saturation



# Film projector

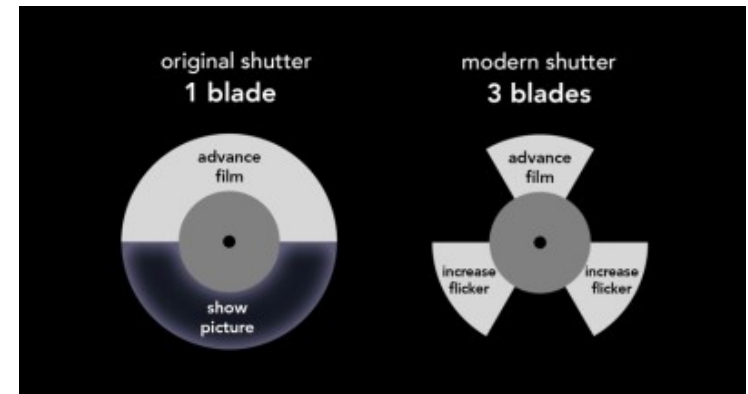
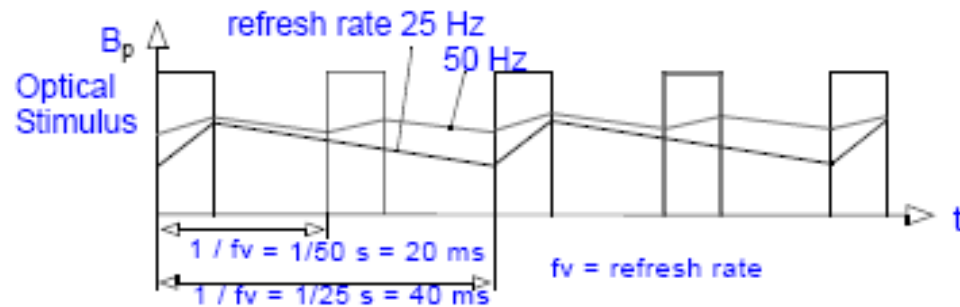
- For video illusion we need 16 images per second (FPS)
- ~1920: silent films use 20-26fps, 1930: 24fps



Why is the projection flickering?

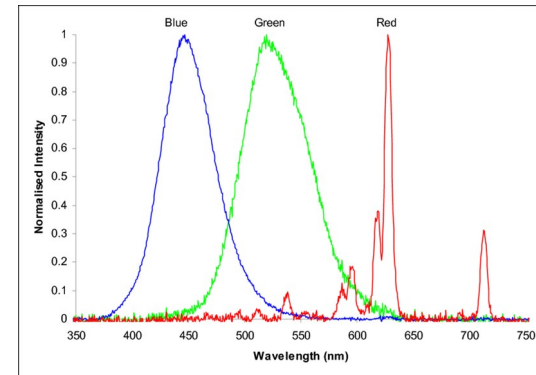
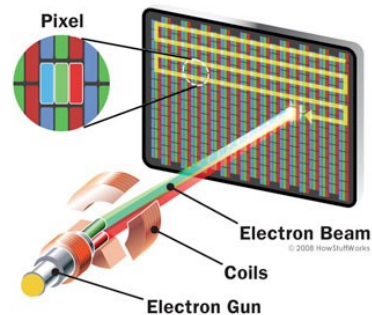
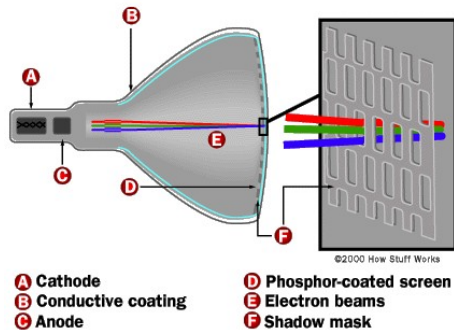
# Flickering

- Shutter closed during film movement
- High illumination change - flickering
- Darker display - higher shutter frame rate



# Cathode displays

- Electron beam traversing matrix of fluorescent particles
- When a particle (pixel) is hit, it briefly glows
- To maintain realism, the beam has to refresh the screen fast enough (refresh frequency)
- CRT monitors (<50Hz flickering) (~100Hz no flickering)

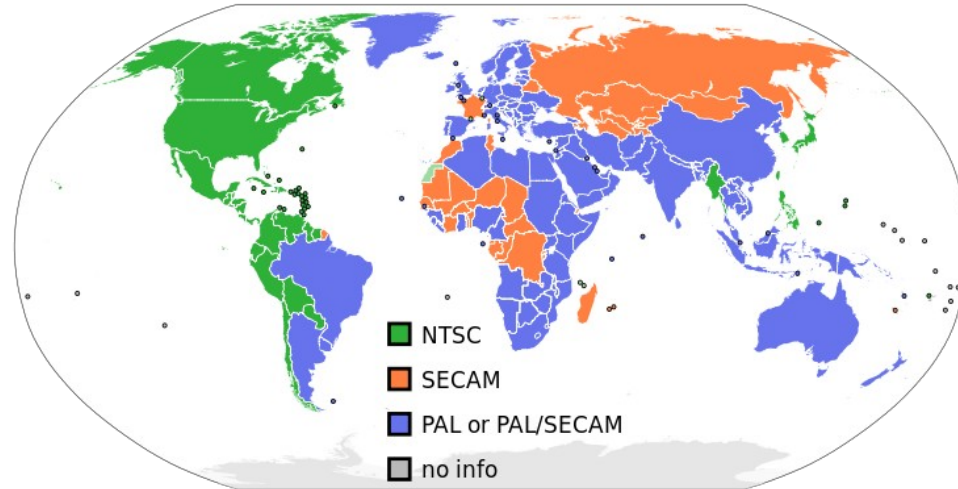


# Encoding color

- Composite video
  - Suitable for lower bandwidth
  - Luminosity and color mixed in common signal
  - Channel cross-talk
  - Analog TV: NTSC, PAL, SECAM
- Component video
  - Separate signals for color channels
  - Better image reproduction, no cross-talk
  - BNC, RCA, VGA



# Analog television formats

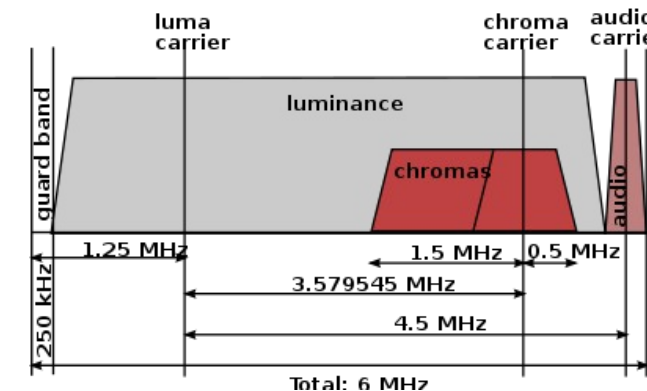
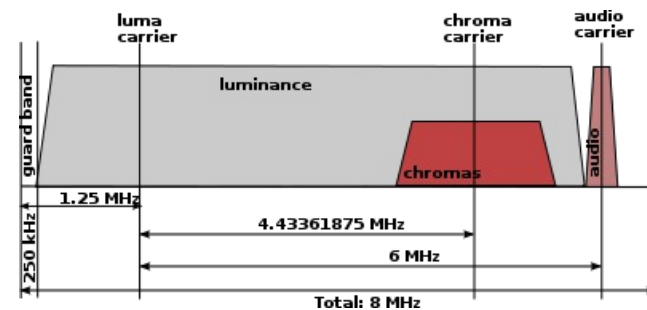


TV standard	FPS	# lines	Frequency band (MHz)	Channel allocation (MHz)		
				Y	I or U	Q or V
NTSC	29.97	525	6.0	4.2	1.6	0.6
PAL	25	625	8.0	5.5	1.8	1.8
SECAM	25	625	8.0	6.0	2.0	2.0



# Analog television

- PAL
  - Phase Alternating Line
  - 625 lines per image
  - 25fps, aspect ratio 4:3, interlaced
  - YUV color space
- NTSC
  - Used in North America
  - YIQ color space
  - 525 lines (29.97fps), interlaced
  - Color tone shift due to geography and weather
  - To reduce channel cross-talk the chroma phase is alternating

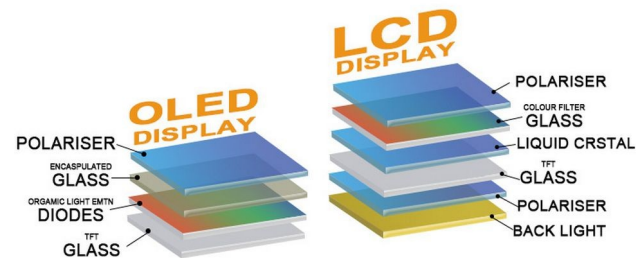
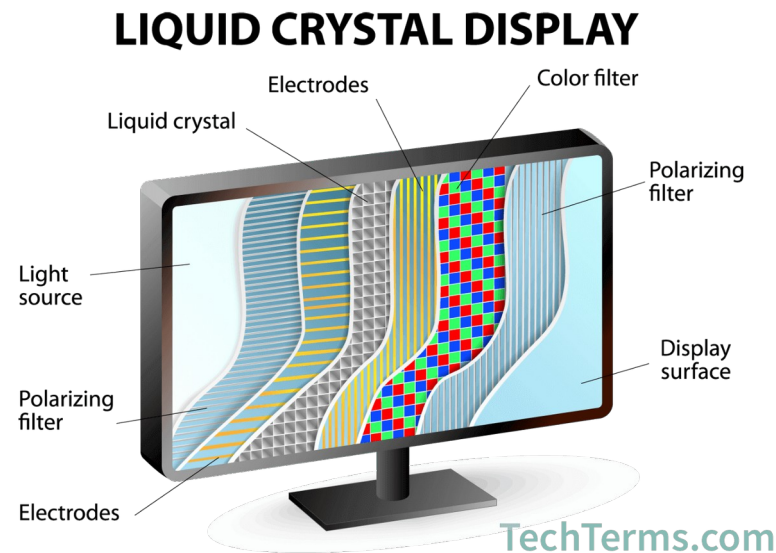


# Digital video

- Storing on digital devices
- Direct manipulation (de-noising, cutting, etc.)
- Inclusion in multimedia applications
- Direct access to different parts of videos
- Copying does not degrade quality
- Easier decoding, better noise tolerance

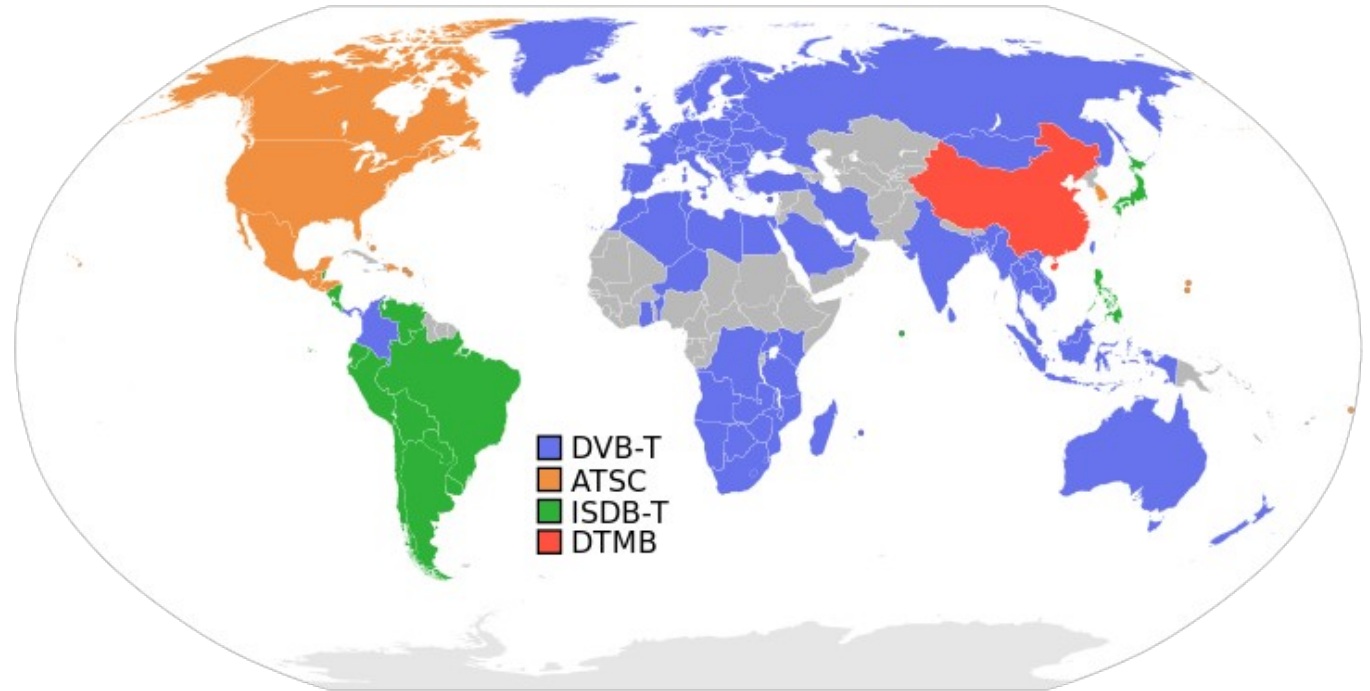
# Flat panel displays

- Liquid crystal (LCD)
  - Fluorescent backlight
- Light-emitting diode (LED)
  - LED backlights
  - Still LCD
- Organic LED (OLED)
  - OLEDs for individual pixels
- *(Plasma)*

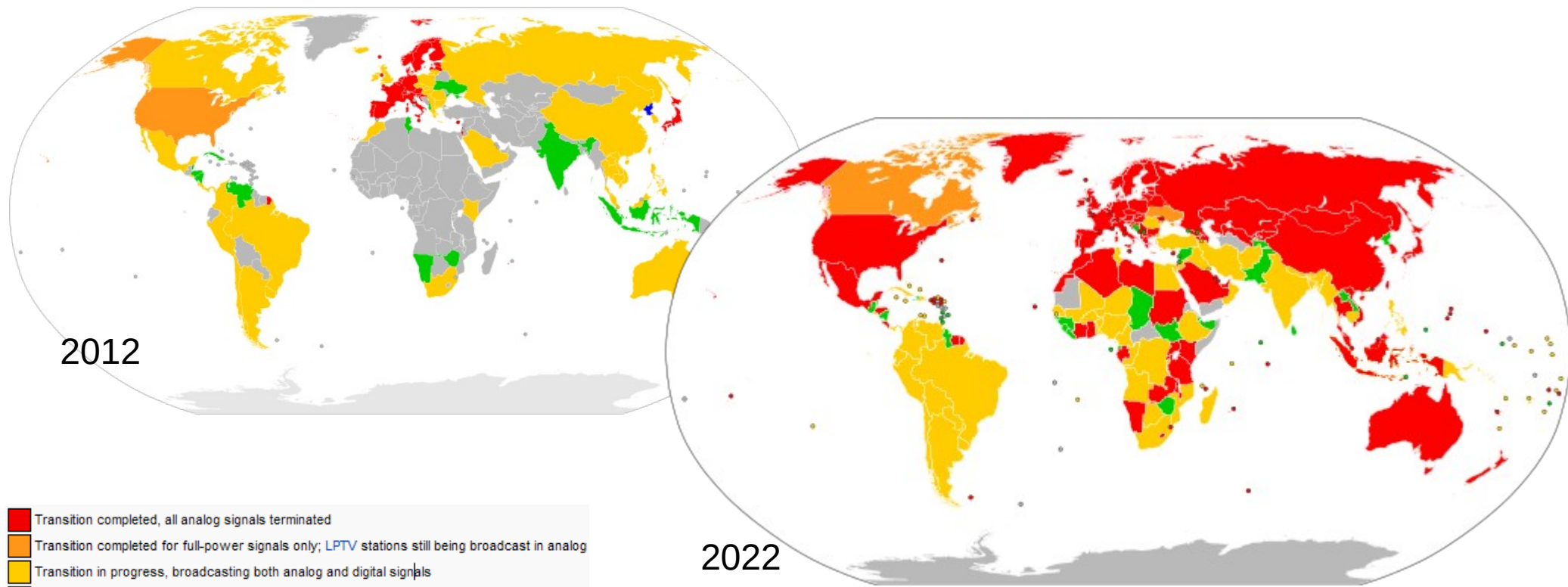


# Digital terrestrial television (DTT)

Standards: DVB-T, ATSC, ISDB-T, DTMB



# Transition to digital television



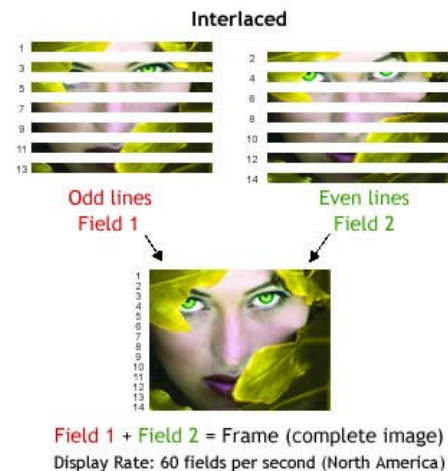
- Transition completed, all analog signals terminated
- Transition completed for full-power signals only; LPTV stations still being broadcast in analog
- Transition in progress, broadcasting both analog and digital signals
- Transition not yet started, broadcasting analog signals only
- Does not intend to transition, broadcasting analog signals only
- No information available

# HDTV

- High resolution digital television
- Increase width of viewing angle
- First generation Sony (1970) - analog
- Standard for digital television
  - DVB, ATSC
  - Codec MPEG-2 for video compression
  - Resolution up to 1920×1080 (progressive)
  - Enables progressive and interleaved encoding (progressive default)
  - Aspect ration 16:9 (anamorphic)

# Encoding rows

- Interlaced
  - Split image into two - odd and even lines
  - Reduce flickering on analog displays
  - Less space
  - Quick changes cause »combing« effect
- Progressive
  - Store each image separately
  - More space



# Interlaced video example



(a)



(b)



(c)



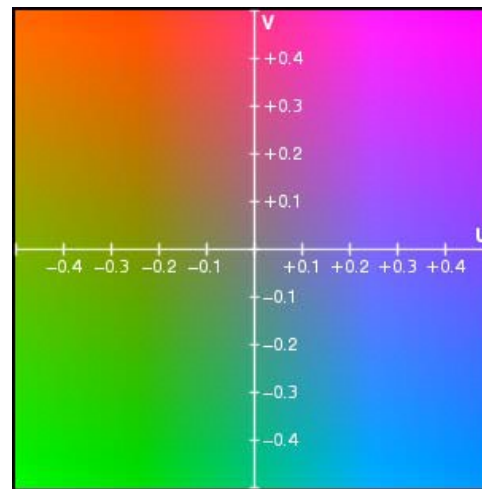
(d)

(a) Image from video, (b) field 1, (c) field 2, (d) difference between 1 and 2

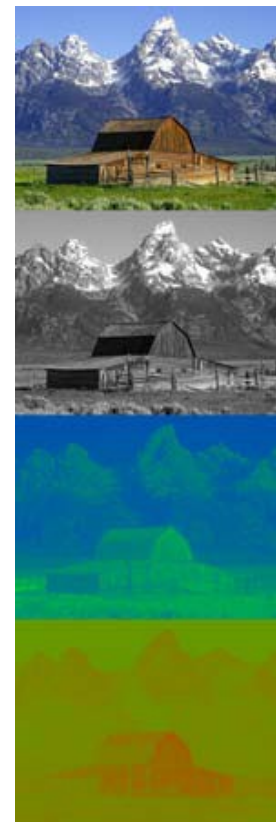


# Color coding

- De-correlated luminosity and color
- YUV, YIQ, YCrCb
  - Y is illumination
  - UV/IQ/CrCb are chroma components
- Conversion from RGB to YUV :
  - $Y=0.229R+0.587G+0.114B$
  - $U=0.492(B-Y)$
  - $V=0.877(R-Y)$

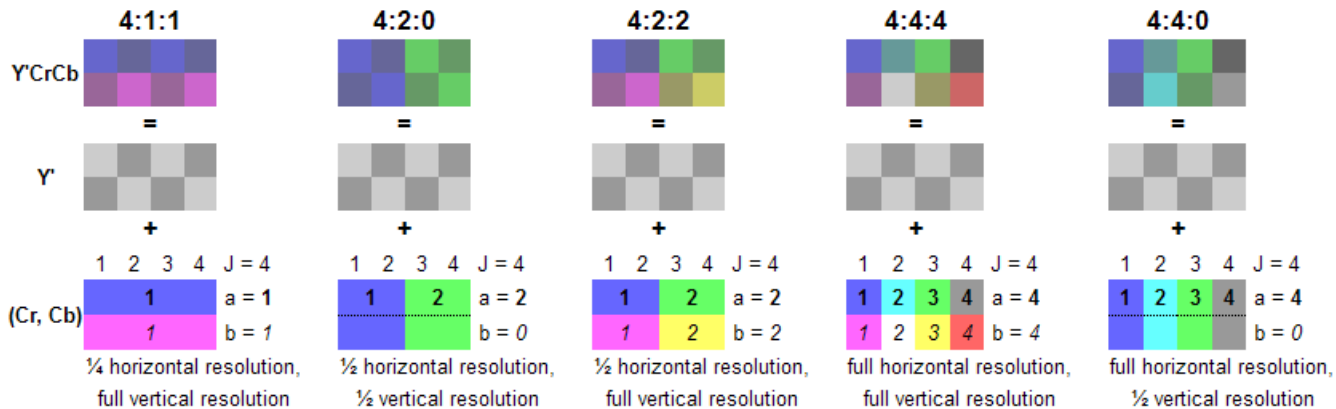


UV plane  $Y=0.5$



# Color sub-sampling

- Humans are more sensitive to changes in illumination than in color
- Color can be sub-sampled - reduce size
- How many chroma values are actually retained
  - J: horizontal sampling frequency (region width, e.g. 4)
  - a: number of chroma samples (Cr, Cb) in the first line of J pixels
  - b: number of additional chroma samples in the second line of J pixels



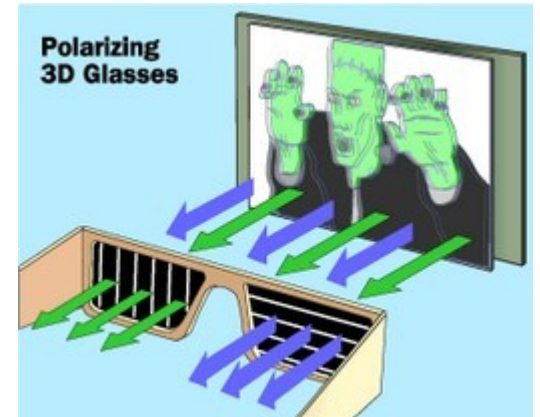
# 3D video

- Stereoscopic photography
  - Two images at two positions (50 mm to 75 mm apart)
  - Impression of a third dimension
- Video technology
  - Wearable technology
  - Autostereoscopy



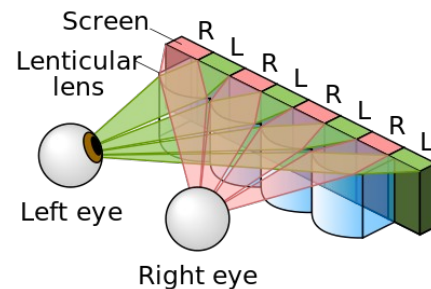
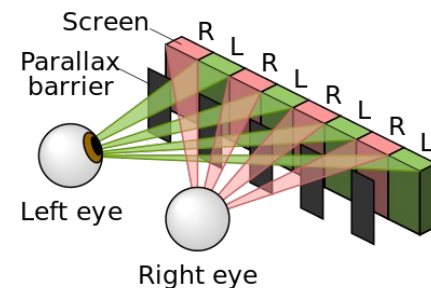
# Wearable 3D video technology

- Anaglyph glasses (passive)
- Polarized glasses (passive)
- Binocular HMD (active)
- Active shutter glasses (active)



# Autostereoscopy (Glassesless 3D)

- Eye/head tracking (active)
- Parallax barrier (passive)
- Lenticular lens (passive)

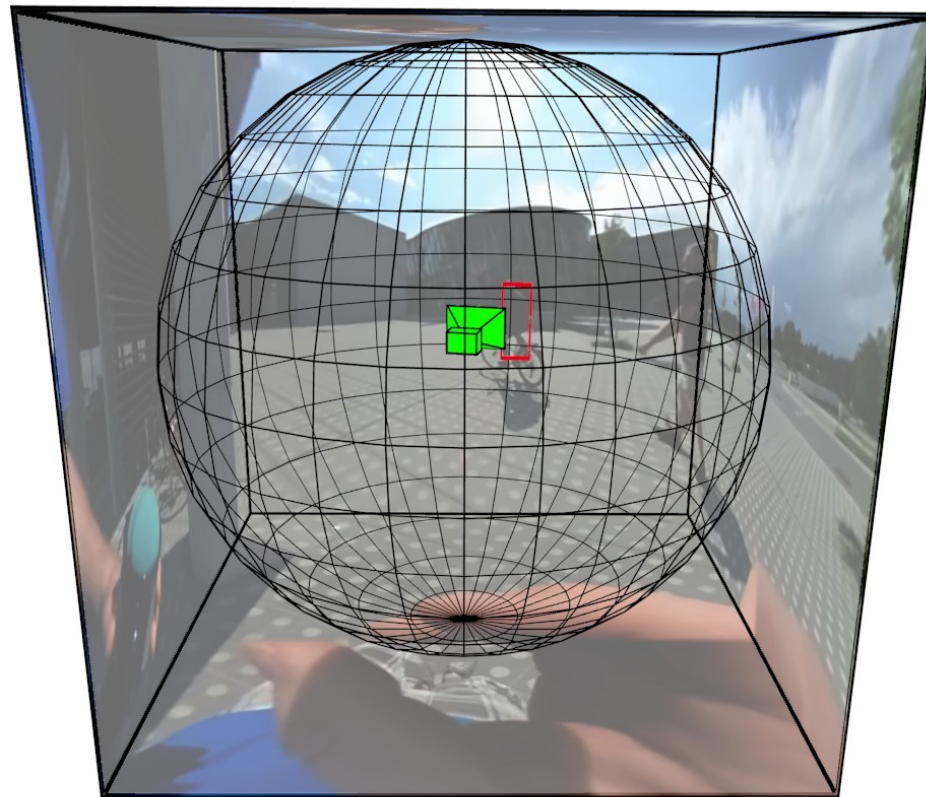


# Problems with 3D video

- Technology
  - Resolution
  - Frame rate
  - Cross-talk
- Usefulness
  - Limited value
- Cost
- Health
  - Motion sickness
  - Headaches
  - Nausea
  - Disorientation

# Omnidirectional video

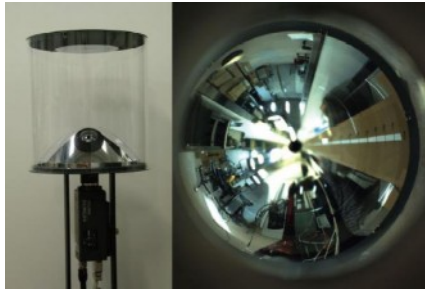
- Single camera origin
- Projection sphere
- Interactive experience





# Omnidirectional video acquisition

- Catadioptric camera
- Multi-camera
  - Wide-lens (less cameras, low resolution)
  - Narrow-lens (more cameras, high resolution)

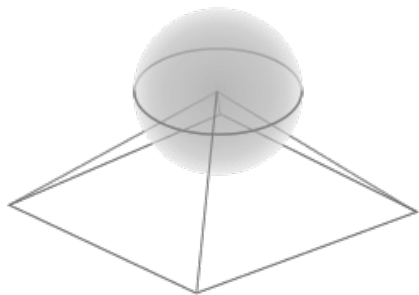


- Calibration (factory, post-processing)

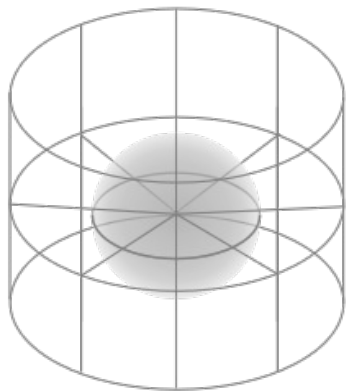


# Re-projection approaches

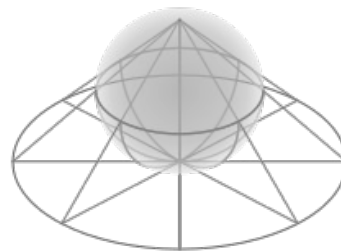
Flat



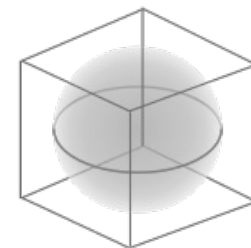
Equirectangular



Stereograph

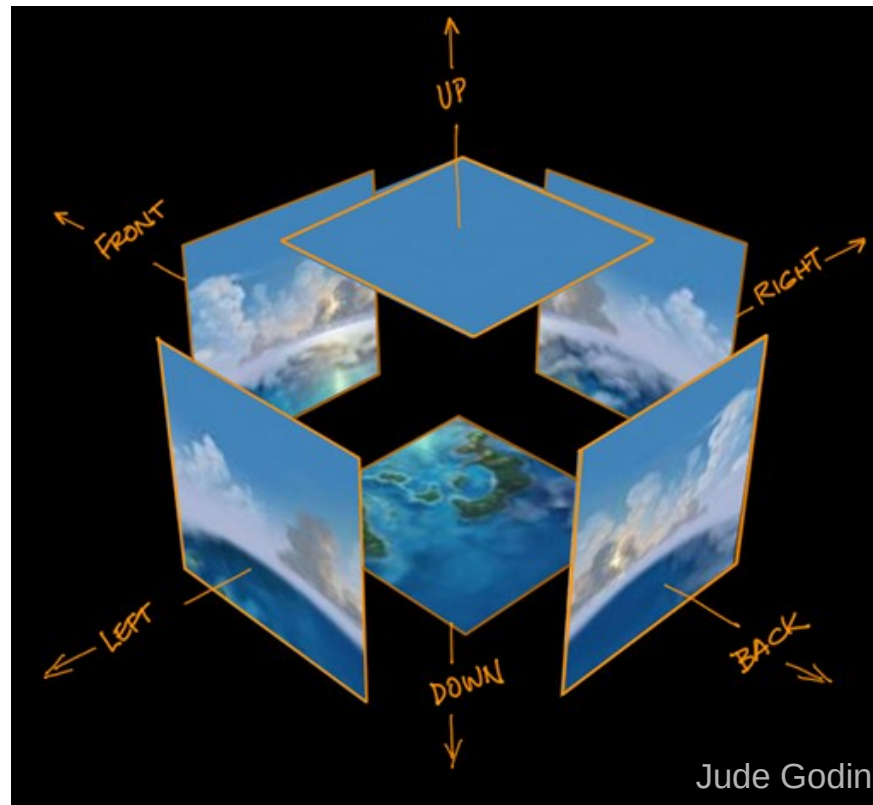


Cubemap



# View generation

- Rendering
  - UV mapping
  - Cubemap
- Limitation
  - View angle
  - Resolution



# Conclusion

- Interest
  - USA, 2016 - 90% think 360° video improves experience
  - HMD, virtual reality
- Use cases
  - Panoramas (aesthetic)
  - Live entertainment - BBC
  - Sports and tourism
  - Consumer-created (travel)

