Multimedia-Systems:
Video

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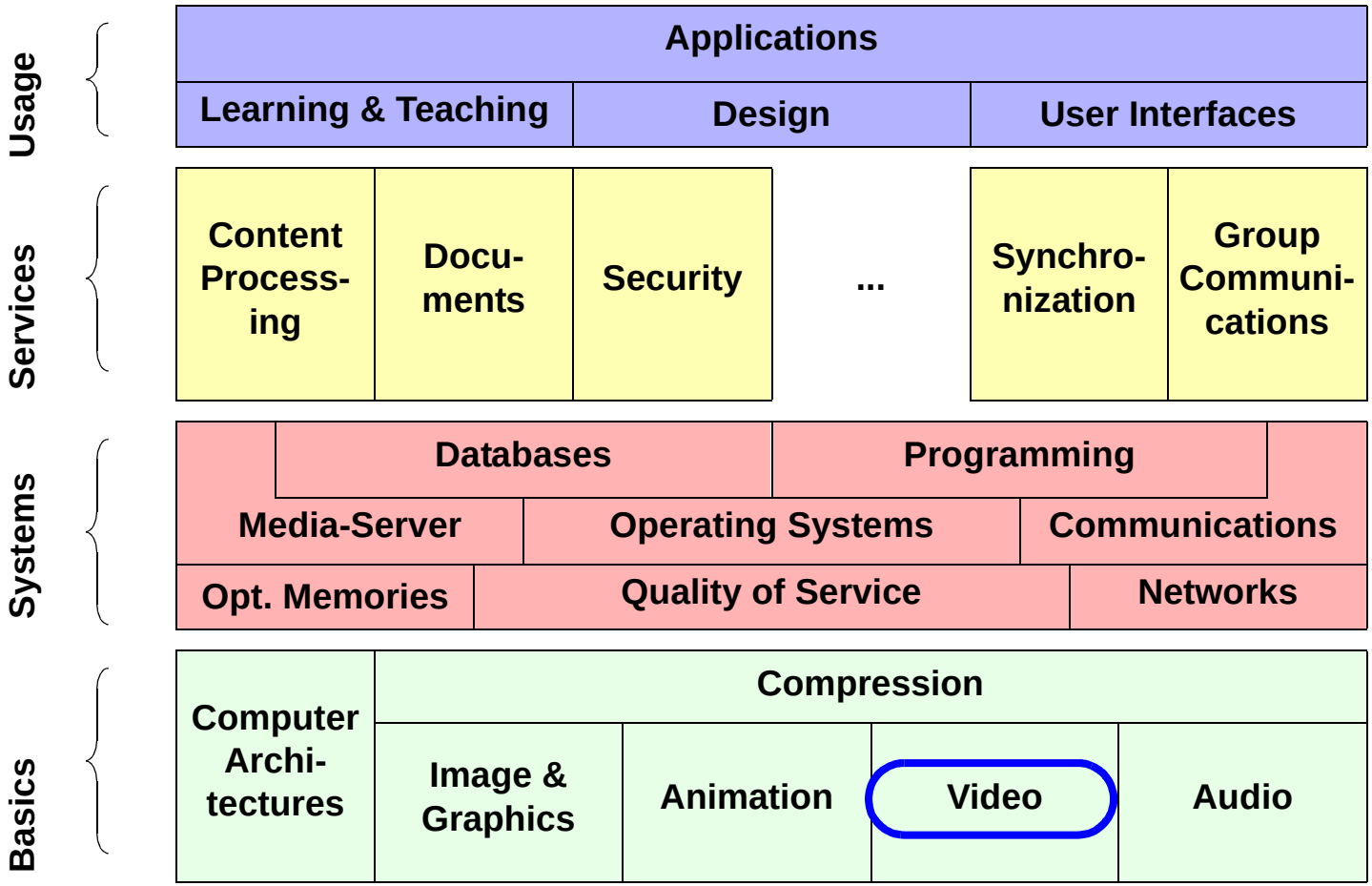
Scope



Contents

1. Intention

to provide

- **basic understanding of the media „video“ and its characteristics**
- **to describe (in general) video standards of today and tomorrow**

not to provide

- **lecture on TV or digital TV**

look at “video” as the process of:

- **generation -> transmission -> perception**
- **with**
  - perception
    - which is influenced by output device and human physology
  - generation
    - both by capturing or synthesis
  - transmission
    - in the analog and digital world

2. Human Visual Perception

Human eye:

- **build up of**
  - cones to perceive color
  - rods to perceive brightness
- **minimal distance between two uvula**
  - 0.004 mm
- **recepts single images and sequences**

Specification of video systems determined by:

- **Characteristics and limitations of human visual perception**
  - spatial resolution
  - brightness
  - black/white vs. color
- **Human information processing**
  - interpolation
  - pictures and events that can still be identified as separate
  - impression of coherent motion

Visual Perception: Resolution and Brightness

Spatial resolution (of single points) depends on:

- **Image size**
- **Viewing distance**

Perception of brightness:

- **Higher than perception of color:**
  - Especially high perception of bright edges
  - Perception decreases with brightness of surroundings
- **Different perception of the primary colors**
  - Relative brightness:
    green : red : blue = 59% : 30% : 11%

Example:

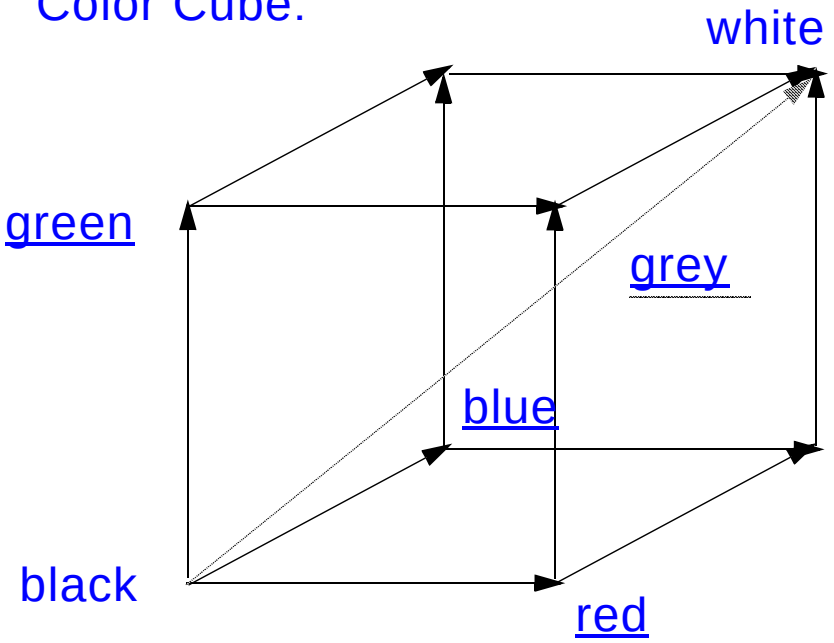
- **2 lines with distance of 1 mm are recognized as two lines if:**
  - Viewing distance < 3m or
  - Viewing angle >10°

Visual Perception: Colors

Each color defined by mix of primary colors:

- **Red**
- **Green**
- **Blue**

Color Cube:

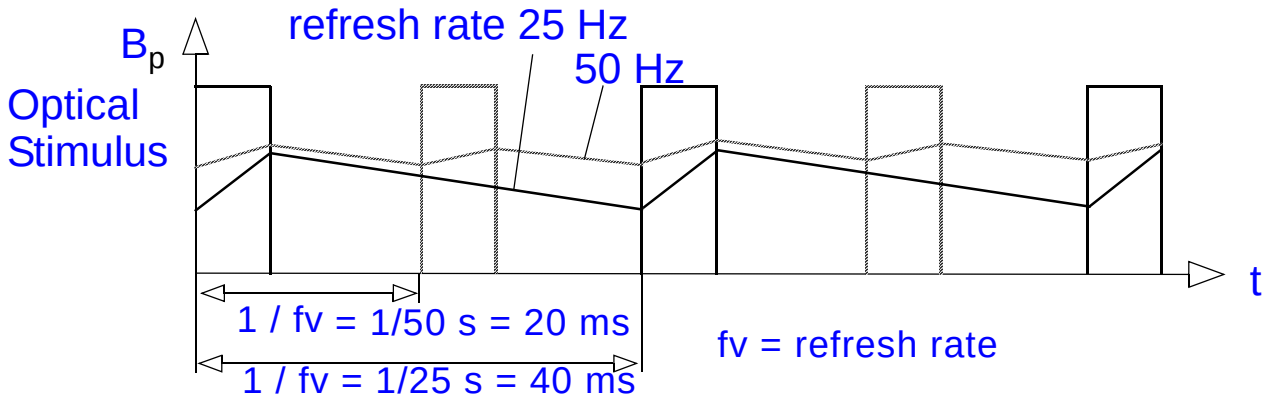


E.g. white is represented by:

- **red : green : blue = 100% : 100% : 100%**

Visual Perception: Temporal Resolution

- **effects caused by inertia of human eye**
- **for a sequence of images (= „frames“):**
  - no identification of single frames if refresh frequency high enough
  - perception of 16 frames/s as continuous sequence
- **special effect: Flicker**
  - perceived if frame rate or refresh rate of screen too low (< 50 Hz)
  - especially in large bright areas
  - maybe reduced by addional interruptions (cinema: 3 x 16 Hz), interleaving or additional buffering (100 Hz TV sets)



- **Higher refresh rate requires:**
  - Higher scanning frequency
  - Higher bandwidth

Visual Perception: „Kell Effect“

Raster interference between:

- Raster of scanning system and
- Raster of scanned image

Correct reproduction of line if:

- Line at scanning line

Incorrect reproduction of line if:

- Line between scanning line

i.e. Kell-factor:

- Ratio: number of active lines to number of vertical lines
- K = 0.64
- Europe: 625 x 0.64 = 400 active lines
- USA and Japan: 525 x 0.64 = active 336 lines

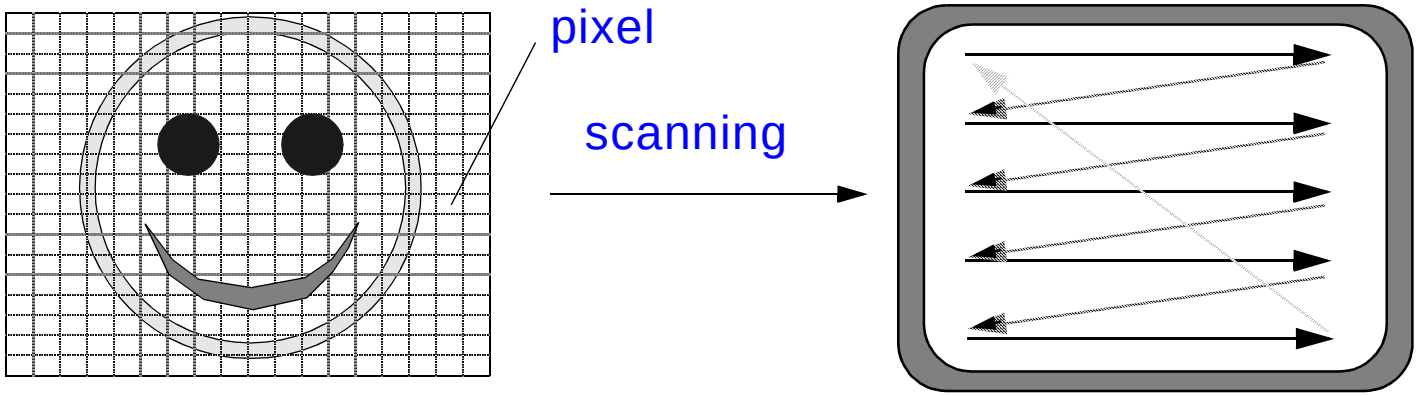
Visual Perception: Further aspects

perception is also influenced by:

- **viewing distance**
- **display ratio (width / height - 4 /3 for conventional TV)**
- **number of details still visible**
- **spatial (3D) impression**
- **intensity (luminance)**
- **dynamics of changes**
- **...**

3. Video Generation / Capturing

- **generation / capturing / storage / manipulation / transmission / display of single images based on:**
  - grey-scale or color values of its pixels



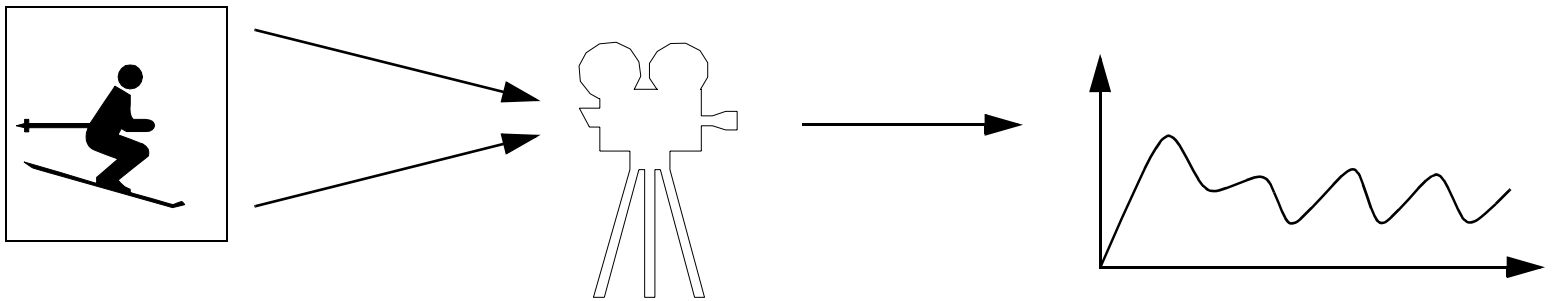
-> results in a sequence of values for every single image

- **basic knowledge (pixel, representing pixel values by a certain value / number of bytes ...) known from lecture „Images“**

- **mention:**
  - due to the characteristics of todays television systems, we will also deal with analog methods
  - video signal may also be generated „analytically“ - think of your computer display as a TV set / early personal computers could even use TVs as monitors

Capturing: Video Cameras

- **Intention:**
  - Transformation of a two-dimensional picture into a one-dimensional electrical signal by means of a scanning process (e.g. line by line)



- **Principle of operation:**
  - Plate of photosensitive material
  - Evolving of a charge in the material depending on amount of light at each spot
  - Charge read out:
    - Emitting an electron beam onto the plate
    - Collecting generated signals
  - Alternative: silicon chip (Charge coupled devices - CCD)

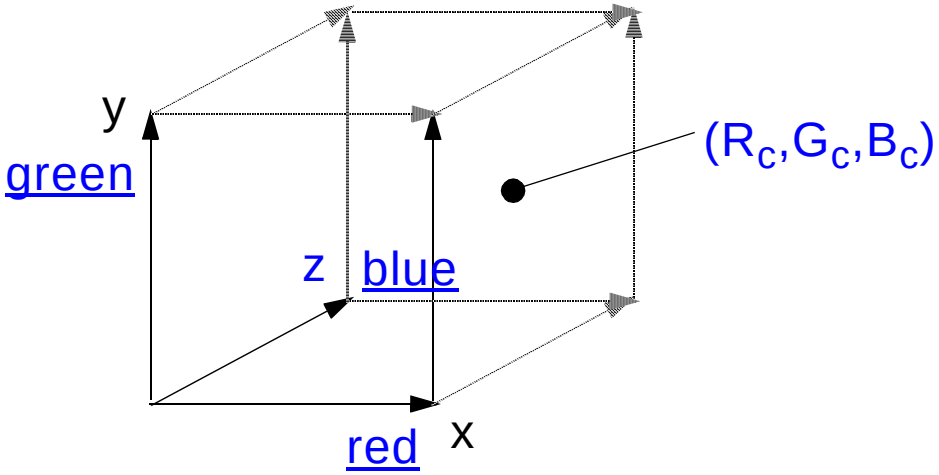
4. Video Coding and Transmission

Basic question:

- how to represent video as continous signal
- how to transmit it via a single „channel“

RGB color coding:

- Color code = coordinates of a point within the color cube



- Three independent components for red (R_c), green (G_c), and blue (B_c)
- I.e. code is a tripel (R_c,G_c,B_c),
  R_c, G_c, B_c being the contributions of the primary colors
- Number of bits per component determines color depth

Color Coding: Luminance/Chrominance Principle

Code consists of *luminance* and *chrominance* components:

- **Luminance component: brightness of pixel**
- **Chrominance difference components: color of pixel**
  - Hue: which color
  - Saturation: depth of color

Examples:

- **YUV coding:**
  - Y = 0.30R + 0.59G + 0.11B (luminance)
  - U = (B - Y) x 0.493(chrominance 1)
  - V = (R-Y) x 0.877(chrominance 2)
- **YIQ coding:**
  - Y = 0.30R + 0.59G + 0.11B(luminance)
  - I = 0.60R - 0.28G - 0.32B(chrominance 1)
  - Q = 0.21R - 052G + 0.31B(chrominance 2)

Color Coding: Luminance/Chrominance (cont.)

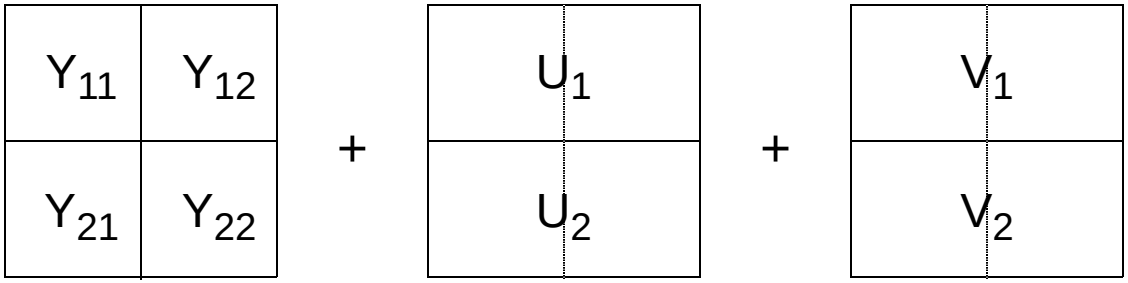
Different resolutions for luminance and chrominance possible:

- **Luminance Y:high resolution**
- **Chrominance U, V: lower resolution**

Examples:

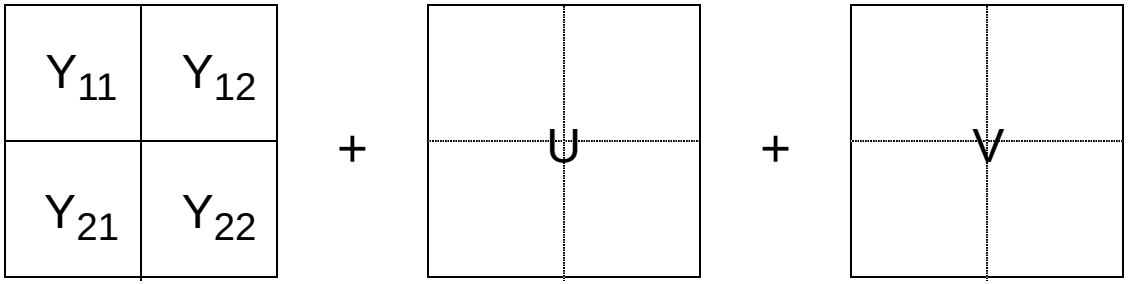
- **4:2:2: double resolution for luminance**

Coding of four pixels:



- **4:1:1: quadrupel resolution for luminance**

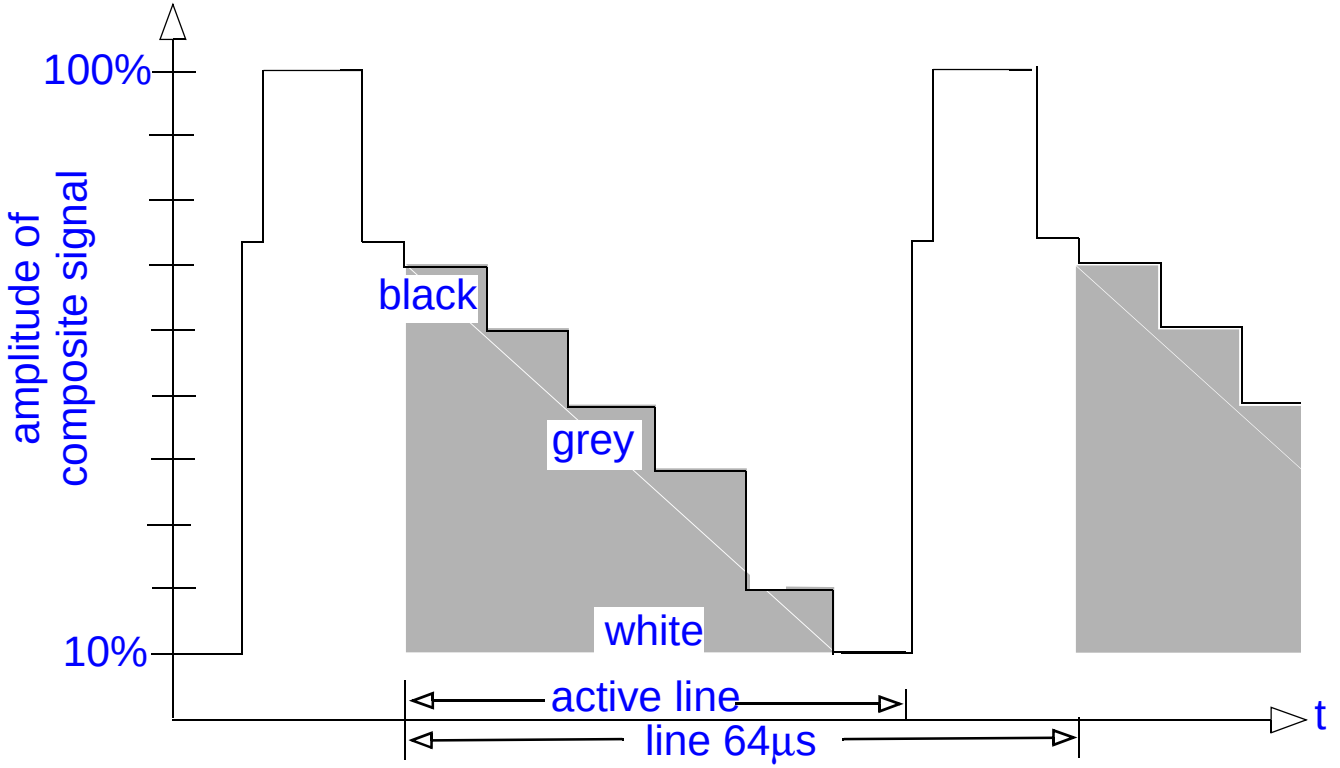
Coding of four pixels:



Composite Signal

Composite signal:

- **Image data**
- **Sampling data**
- **Synchronization data**

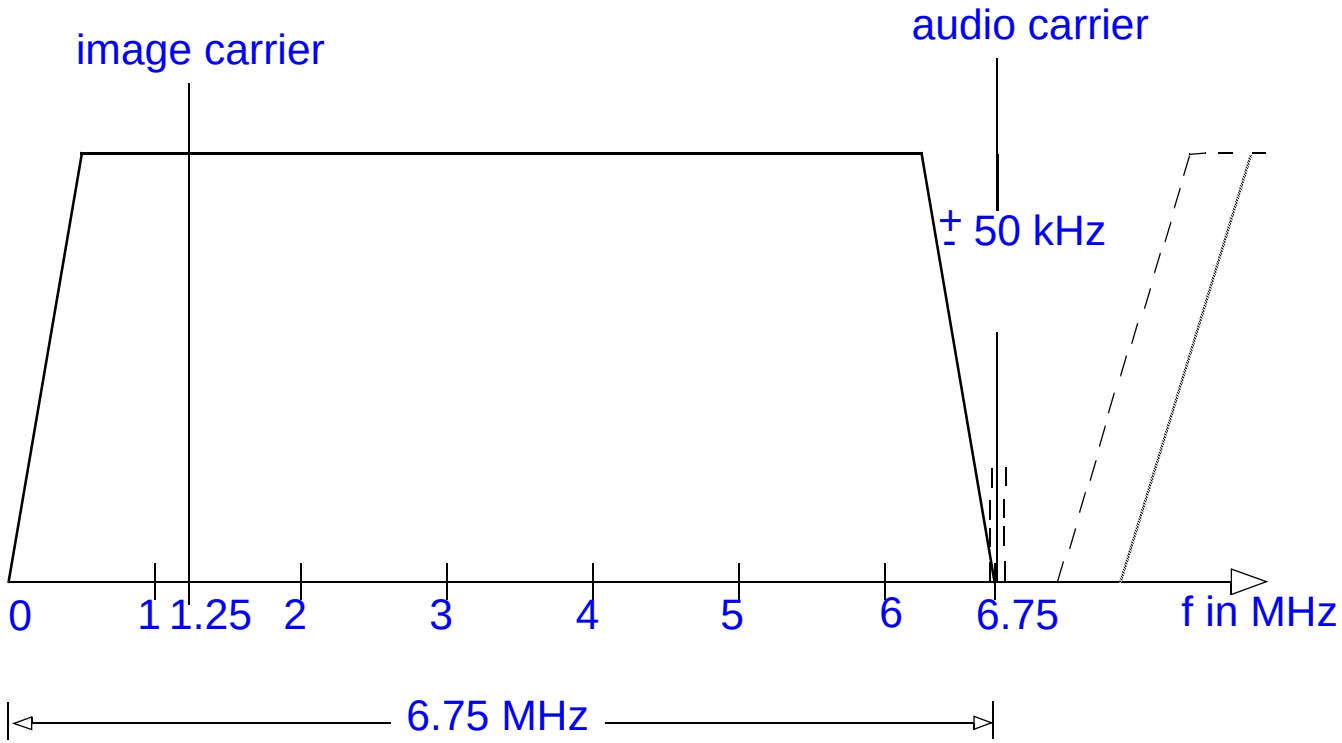


Composite Signal

Signal modulation:

- **Amplitude modulation**

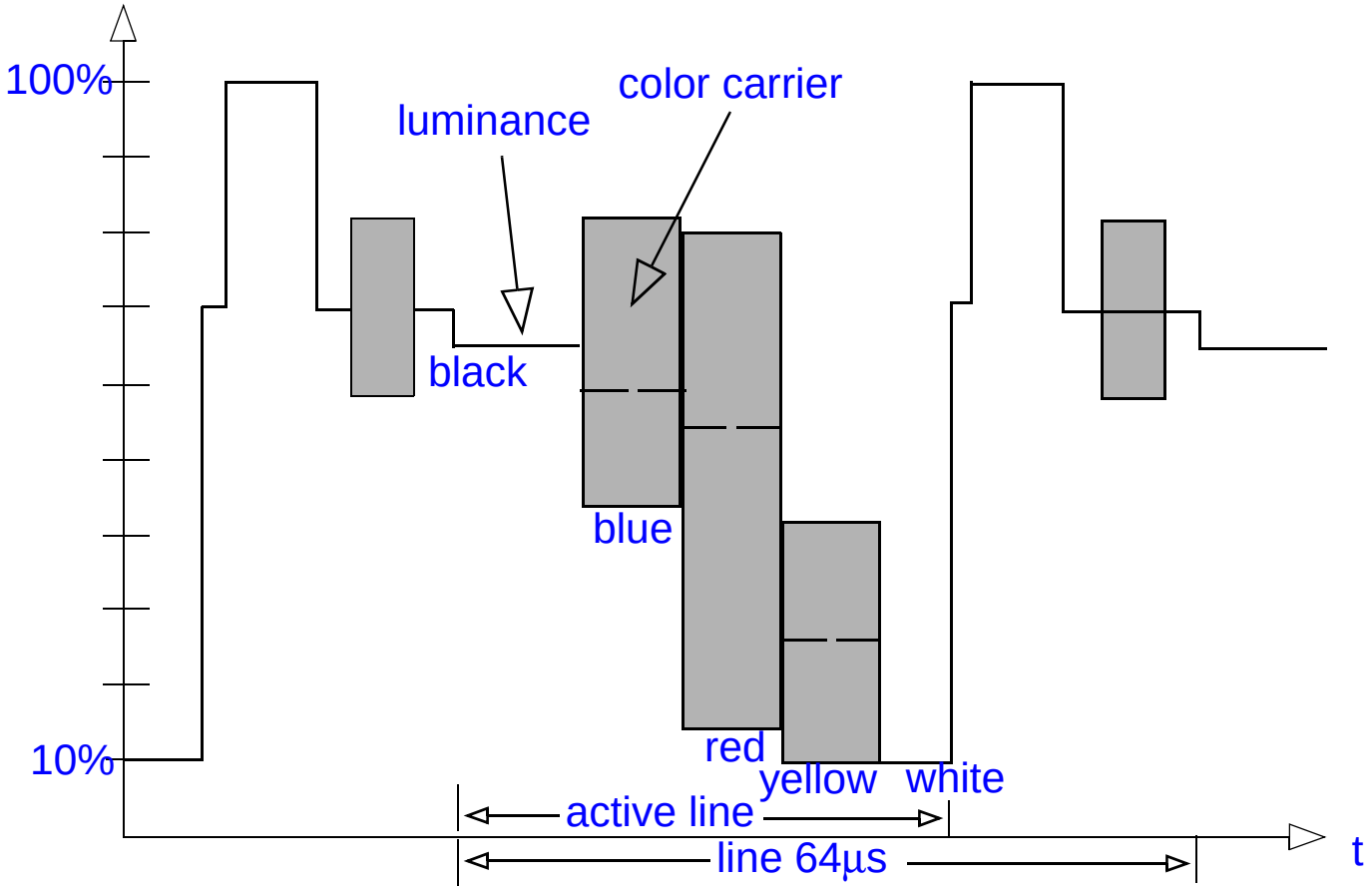
Spectrum of composite signal:



Composite Coding

<u>One</u> signal:

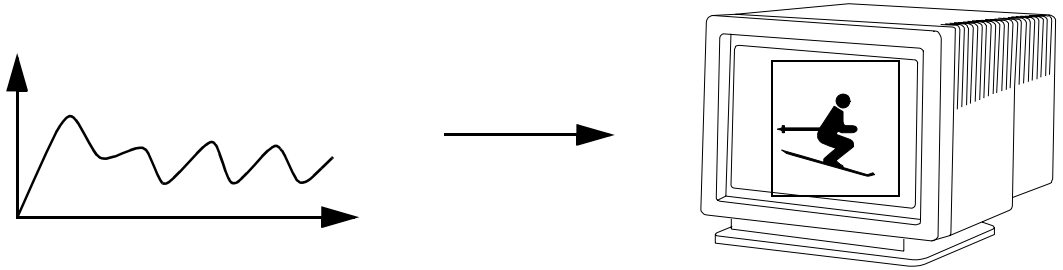
- **Transmission of luminance and chrominance over one channel**
- **„Composite Color Signal“**



5. Video Presentation

Cathode Ray Tube (CRT):

- Transformation of one-dimensional electrical signal into two-dimensional visual image



- Principle of operation:
  - Transformation of signal into electron emission of a cathode
  - Light emission in a layer of fluorescent material caused by electrons
- Variants:
  - Black-and-white: Signal amplitude proportional to image brightness
  - Color: Signal includes brightness and color information (luminance and chrominance)

nowadays: LCD or TTF Displays:

- with analog interface (for compatibility)
- with digital interface (direct transmission from video memory)

Video Presentation: Adapter Standards

history:

- Hercules Monochrome Adapter
- Color Graphics Adapter (CGA) - 320x200 x 4 colours
- Enhanced Graphics Adapter (EGA) - 640x350 x 16 colours

actual:

- Video Graphics Array (VGA) - 640x480 x 256 colours
- Super Video Graphics Array (SVGA)

actual developments:

- dedicated busses for fast data transfer (Advanced Graphic Port - AGP)
- dedicated video processors (accelarators) that support
  - manipulation of graphic primitives (e.g. rectangle fill)
  - visibility algorithms (e.g. Z-buffer)
  - or texturing algorithms
  - hardware support for MPEG presentation
  - ...

6. Conventional (Analog) Video Broadcast / Television

Transmission Standards:

- NTSC (National Television Systems Comittee)
- SECAM (Sequentiel Colour avec Memoire)
- PAL (Phase Alternating Line)

standard	lines	pixels/line	frames/sec	coding	modul-ation
NTSC	525	700	30	YIQ	AM
Secam	625	864	25	YUV (seq. trans-mission)	FM
PAL	625	864	25	YUV (2-phase sig-nal)	AM

HDTV Standards

European High Definition Multiple Analogue Components (HD-MAC):

- Defined in Eureka Project EU95
- Cooperation of 35 European industry representatives, television, research centers
- ‘Some’ compatibility to existing standards

Japanese Multiple Sub-Nyquist Encoding (MUSE):

- Not open to TV standards
- Vertical resolution: 1125 lines, Frame rate: 60 Hz
- 1992: 1 hour/day broadcasting using MUSE standard

USA:

- Goal: compatibility to NTSC
- Vertical resolution: 1050 lines, Frame rate: 59.94

7. Digital Television / Digital Video Broadcasting

History

- **1982: CCIR international digital television standard**
- **....: HDTV**
- **1995: DVB Digital Video Broadcasting**

Starting point:

- **Combined Digitalization of video signals**

Combined Digitalization of composite black/white signal:

- Video bandwidth: 2 * 5 MHz * 8 bit = 80 Mbit/s
  - 5 MHz = bandwidth of B/W TV signal

Combined Digitalization of <u>composite</u> color signal:

- Lower interference with color carrier
- Requires even-numbered multiple frequency of the color carrier
- Sampling frequency: 4 * frequency of color carrier
- Data rate: 4 * 4.43 MHz * 8 bit = 141.8 Mbit/s
  - 4.43 MHz = frequency of color carrier

Combined digitalization vs. Component Coding

- **Drawbacks of combinized digitalization:**
  - Interference between luminance and chrominance data
  - Digitalization technique depends on TV standard
  - No adaptation of:
    - Sampling frequency to bandwidth of single components
    - Data reduction to characteristics of single components

- **New approach: Separate digitalization of single components:**
  - Multiplexing of digitized signals

- **Sampling frequency:**
  - Luminance: 13.5 MHz
  - Chrominance: 6.75 MHz

- **8 bit uniform quantization:**
  - Data rate: (13.5 MHz + 2 * 6.75 MHz) * 8 bit = 216 Mbit/s

Digital Television: Features

- **Vertical resolution:**
  - 625 lines/frame
- **Horizontal resolution:**
  - Luminance: 864 pixels/line (visible: 720 pixels)
  - Chrominance: 432 pixels/line (visible: 360 pixels)
- **Frame rate: 25 frames/s**

- **High data rate**
  - Not compatible to PCM hierarchy (139.264 Mbit/s, 34.368 Mbit/s , …)

Hence: definition of substandards

- **Lower data rates**
- **Lower sampling frequencies**

		substandard 1	**substandard 2**	**substandard 3**
sampling frequency	luminance	11.25 MHz (5/6 of standard)	10.125 MHz (3/4 of standard)	9 MHz (2/3 of standard)
	chrominance	5.625 MHz (5/6 of standard)	3.375 MHz (1/2 of standard)	2.25 MHz (1/3 of standard)
data rate		$180*10^6$ bit/s	$135*10^6$ bit/s	$108*10^6$ bit/s