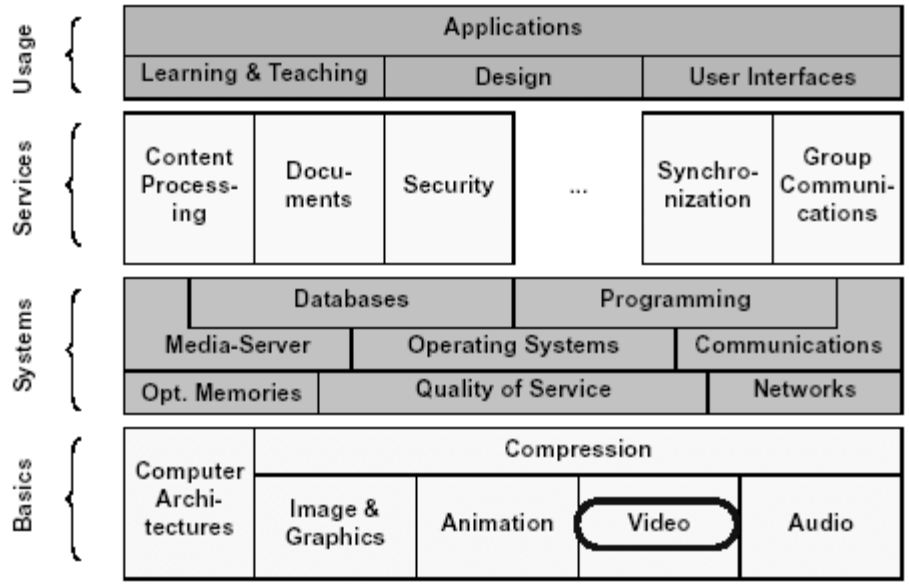
# MULTIMEDIA SYSTEMS

# VIDEO

CSC461/561

## Scope


Usage
Applications
Learning & Teaching
Design
User Interfaces
Services
Content Processing
Documents
Security
...
Synchronization
Group Communications
Systems
Databases
Programming
Media-Server
Operating Systems
Communications
Opt. Memories
Quality of Service
Networks
Basics
Computer Architectures
Compression
Image & Graphics
Animation
Video
Audio

# Video Signal Representation

- In conventional TV sets or monitors, the video signal is displayed using a CRT (Cathode Ray Tube).

- An electron beam sweeps the screen from top to bottom beam carrying the corresponding pattern information, such as intensity in a viewed scene.

# Video Signal Representation

Video signal representation includes three aspects:

- *the visual representation*,
- *transmission*, and
- *digitalization*.

# Visual Representation

Important measures include:

1. **Vertical detail and viewing distance:**

- The geometry of the TV image depends on the ratio of the picture width W to height H, generally referred to as *aspect ratio*. The conventional aspect ratio is 4/3.

# Visual Representation...

2. **Horizontal detail and picture width**
   The picture width for conventional TV is 4/3 of the picture height.

**3. Total Detail Content of the Image**

- *vertical resolution* = number of pixels in the picture height

- Number of pixels in width of picture = *vertical resolution* **x** *aspect ratio*

# Visual Representation...

**4. Perception of depth**

- Perception of depth depends primarily on the angular separation of the images received by the two eyes of the viewer.
- In flat screen of TV, a considerable degree of depth is inferred from the perspective appearance of the object matter.

# Visual Representation...

**5.Luminance and Chrominance**

Color vision is achieved through three signals, proportional to the relative intensities of Red, Green and Blue light (RGB) in each portion of the screen.

# Visual Representation...

- However, during the transmission of the signals from camera to the receiver (display), a different color encoding that uses l*uminance* and two *chrominance* signals are used.

# Visual Representation...

**Temporal aspects of illumination**:

In contrast to continuous pressure waves of an acoustic signal, a discrete sequence of individual pictures can be perceived as a continuous sequence.

# Visual Representation...

To represent visual reality, two conditions must be met:

- Rate of repetition of images must be high enough to guarantee smooth motion from frame to frame.
- The rate must be high enough so that persistence of vision extends over intervals between discrete flashes.

# Visual Representation...

**Continuity of Motion**:

- We perceive continuity of motion at any frame rate faster than 15 frames per second.

- Smooth video motion is achieved at 30 frames per second.

# Visual Representation...

Movies use 24 frames per second and have a jerkiness especially when large objects are moving fast and close to the viewer,

The NTSC (National Television Systems Committee) standard for motion video signal specified frame rates of 30/sec, as compared to 25/sec for the European PAL system.

# Computer Video Formats

**Computer Video Controller Standards:**

- Color Graphics Adapter (**CGA**) has a resolution of 320x200 pixels with simultaneous presentation of 4 colors. The storage capacity per image is therefore:

*320 x 200 pixels x 2bits/pixel = 128000 bits = 16,000 bytes*

# Computer Video Formats...

- The Enhanced Graphic Adapter (**EGA**) supports a resolution of 640x350 pixels with 16-color presentation resulting in a storage capacity of 112,000 bytes per image.

# Computer Video Formats...

- The Video Graphic Array (**VGA**) works mostly with a resolution of 640x480 pixels and can display 256 colors simultaneously.

  The monitor is controlled through an RGB output. The storage capacity per image is then 307,200 bytes.

# Computer Video Formats...

- The Super VGA (**SVGA**) offers resolutions up to 1024x768 pixels and color formats up to 24 bits per pixel. The storage capacity per image is then 2,359,296 bytes.

Low-cost SVGA video adapters with video accelerator chips overcome the speed penalty of using a higher resolution.

# Video Transmission...

The oldest standard for transmission and reception of video signals is the NTSC (National Television Systems Committee).

- To encode color, a video signal is a composite of three signals.
- For transmission purposes, a video signal consists of one luminance and two chrominance signals.

# Approaches to Color Encoding:

**RGB Signal:**
Consists of separate signals for red, green and blue colors. Other colors can be coded as combination of these primary colors.

# Color encoding

**YUV Signal**:
Since human perception is more sensitive to brightness than any chrominance information, therefore a coding technique can distinguish between luminance and chrominance.

# Color encoding…

- Instead of three separate colors, the brightness information (luminance Y) is separated from the color information (two chrominance channels U and V).

- The luminance component must always be transmitted because of the compatibility requirements for black and white video.

# Color encoding...

The component division for YUV signal is:

$$Y = 0.30\,R + 0.59\,G + 0.11\,B$$
$$U = (B-Y) \times 0.493$$
$$V = (R-Y) \times 0.877$$

# Color encoding...

Any error in the resolution of the luminance Y is more important than in the chrominance values U and V. Therefore, the luminance values are coded using higher bandwidth than chrominance value.

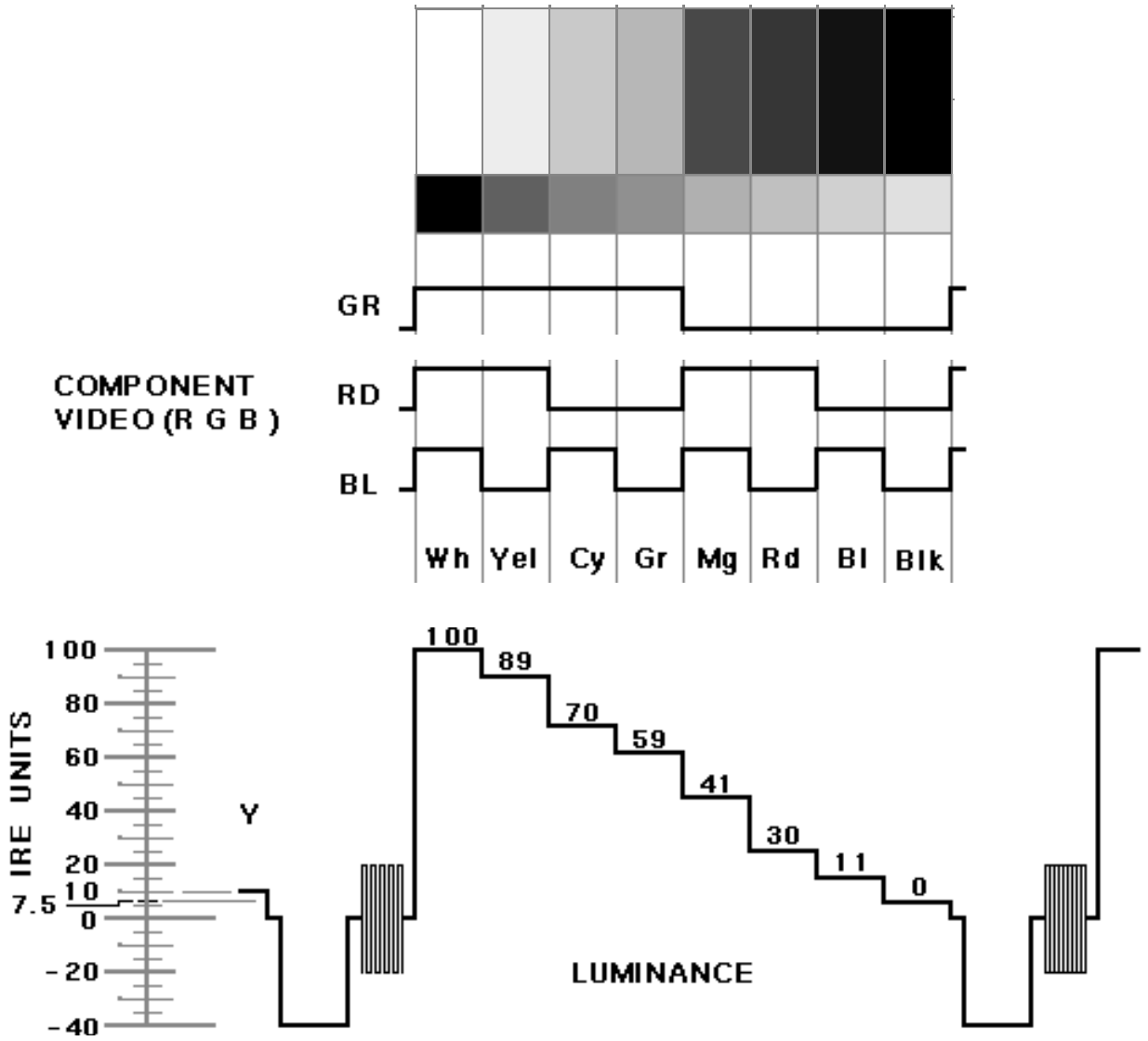
YUV is used in PAL and SECAM systems.

# Color encoding...

**YIQ signal:**

Is a coding similar to YUV signal and is the basis for NTSC format.

$$Y = 0.30R + 0.59G + 0.11B$$
$$I = 0.60R - 0.28G - 0.32B$$
$$Q = 0.21R - 0.52G + 0.31B$$


GR
COMPONENT
VIDEO (R G B )
RD
BL
Wh
Yel
Cy
Gr
Mg
Rd
Bl
Blk
IRE UNITS
100
80
60
40
20
10
7.5
0
-20
-40
Y
100
89
70
59
41
30
11
0
LUMINANCE



Scope

Contents

## Color Coding: Luminance/Chrominance (cont.)

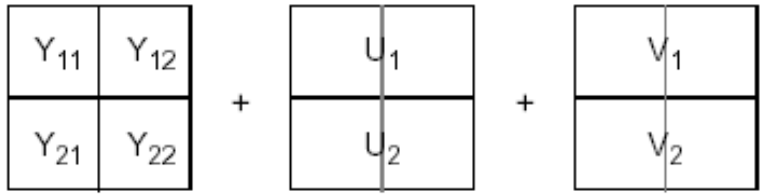
**Different resolutions for luminance and chrominance possible:**

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

**Examples:**

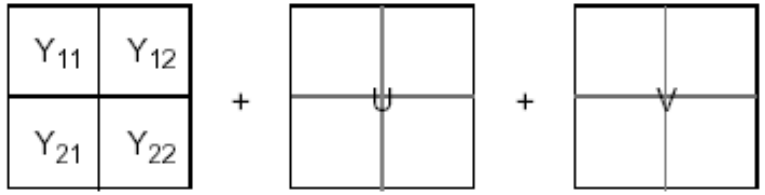
- **4:2:2: double resolution for luminance**

*Coding of four pixels:*




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

*Coding of four pixels:*




- **4:1:0: UV like in 4:1:1, but only for one of two interlaced (half-)frames**

# Color encoding...

Human eye is most sensitive to Y, next to I, next to Q.

Therefore, NTSC allocates 4 MHz of the bandwidth to Y, 1.5 MHz to I, and 0.6 MHz to Q.

# Color encoding...

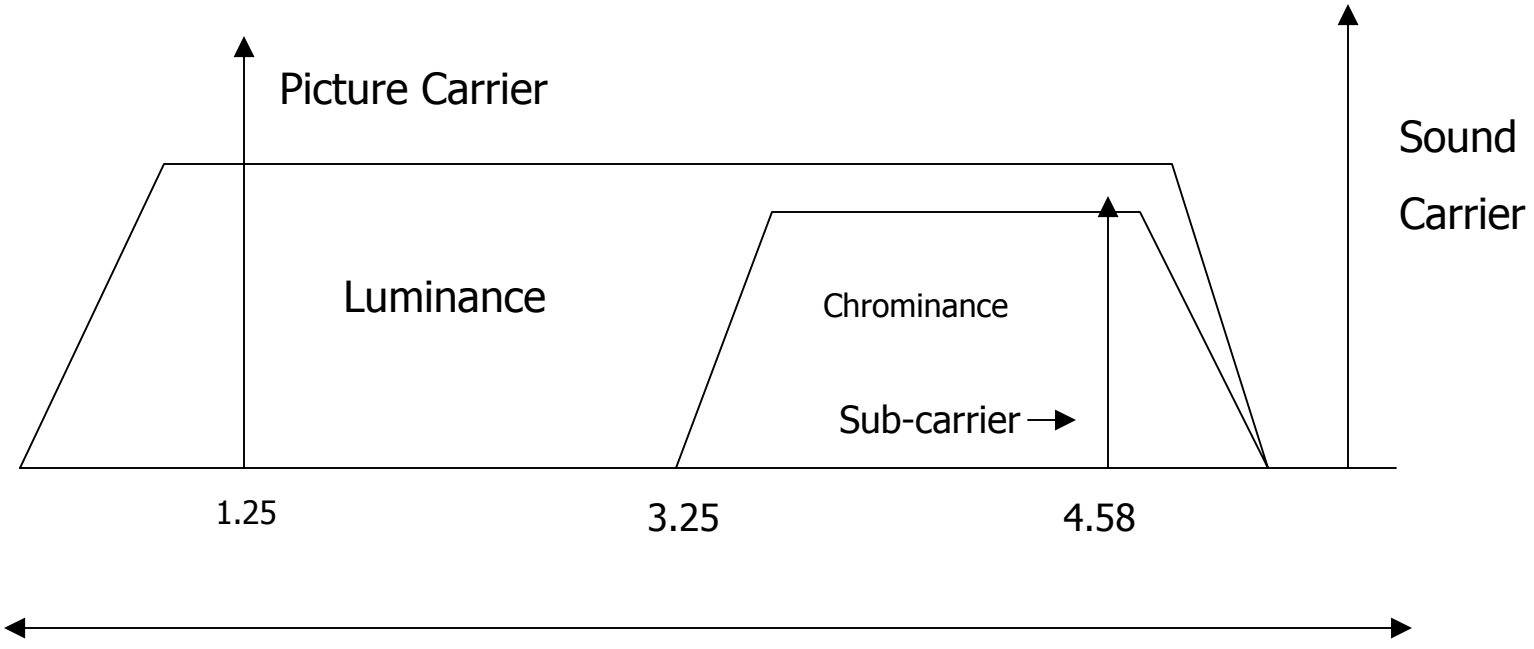
**Digitization:**

- Digitization consists of sampling the gray (color) level in the picture at M x N array of points. Then quantized samples are converted to bit streams.
- The next step in creation of digital motion video is to digitize pictures in time and get a sequence of digital images per second that approximates analog motion video.

# Color TV Systems

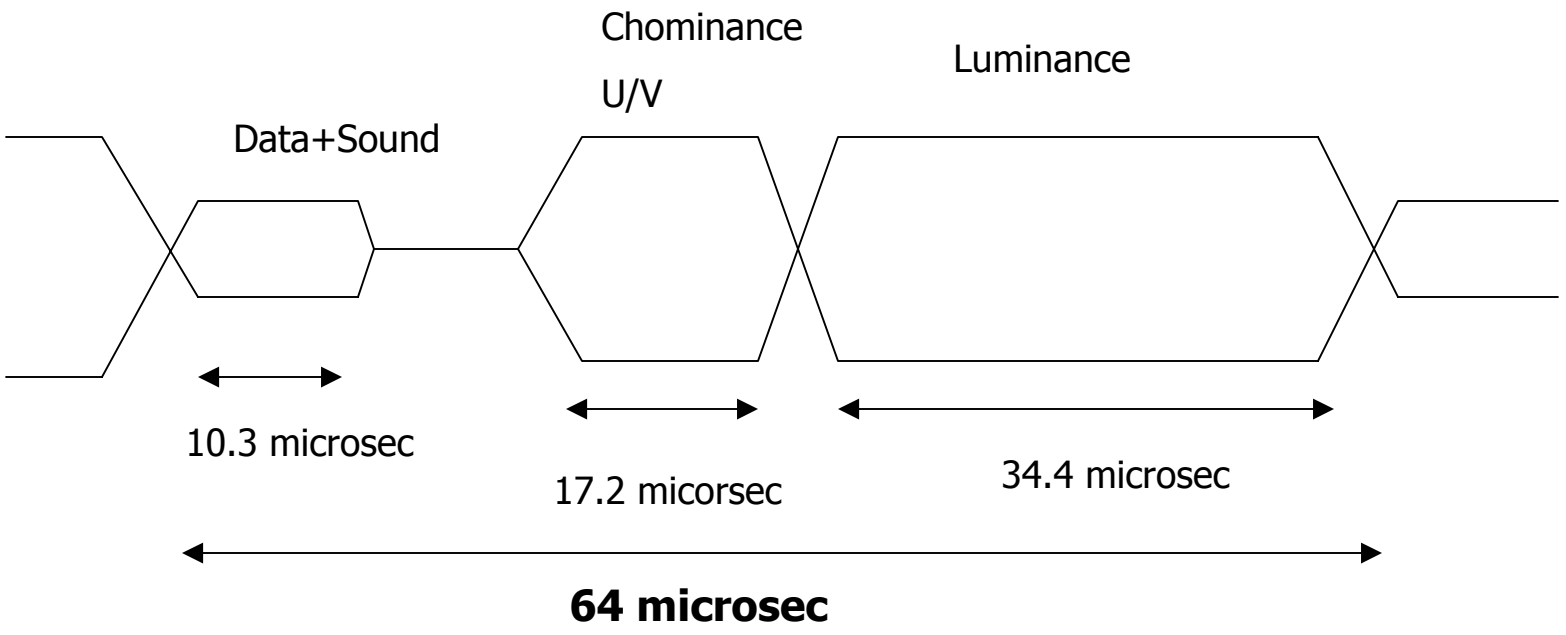
The conventional television systems include:

- **NTSC:** Developed by RCA in US:
  Uses a quadrature amplitude modulation, motion frequency (scan rate) of 30 Hz, total channel bandwidth of 6 MHz and 525 lines per picture. (Used in North and South America and Japan)
  For more information see the NTSC tutorial at:
  http://www.ntsc-tv.com/ntsc-index-04.htm




**Frequency Bandwidth of the NTSC System**

# Time multiplexing of video and sound Signals
(**D2-MAC systems**)



# Color Television...

- **SECAM (*Sequential Color avec Memoire*):** is a standard used in France and Eastern Europe,uses frequency modulation, motion frequency of 25 Hz, a total bandwidth of 8 MHz, and 625 lines per picture.

# Color Television...

- **PAL:** (Phase Alternating Line) was developed by Telefunken in 1963. Is used in Western Europe. Uses quadrature amplitude modulation, uses a total bandwidth of 8MHz and 625 lines per picture.

- **HDTV:** Started with the MUSE system in Japan. In North America the efforts have been toward compatibility with NTSC.



Scope

Contents

# 6. Conventional (Analog) Video Broadcast / Television

**Transmission Standards:**

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

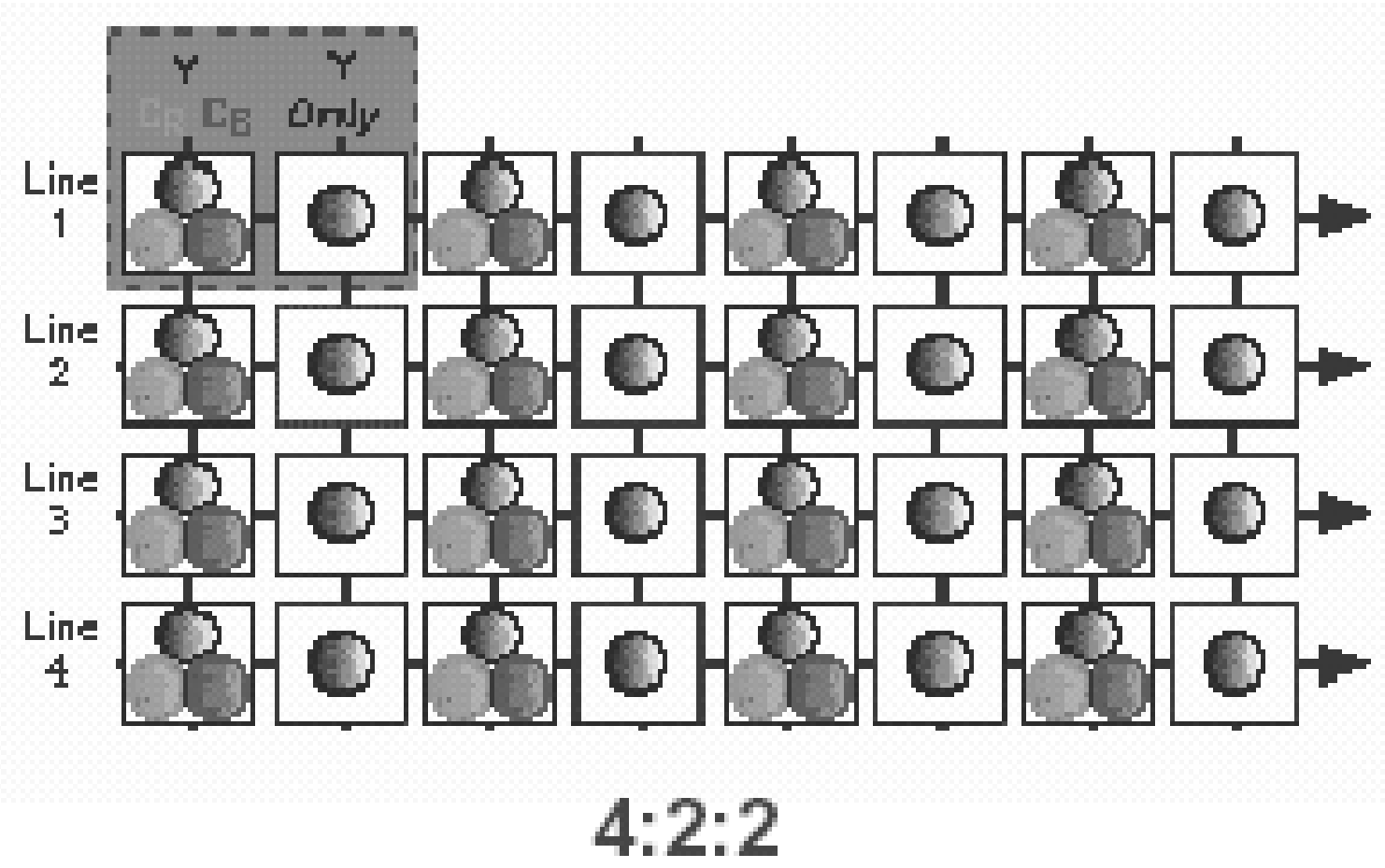
| standard | lines | pixels/ line | frames/ sec | coding | modul- ation |
|---|---|---|---|---|---|
| NTSC | 525 | 700 | 30 | YIQ | AM |
| Secam | 625 | 864 | 25 | YUV (seq. trans- mission) | FM |
| PAL | 625 | 864 | 25 | YUV (2-phase sig- nal) | AM |

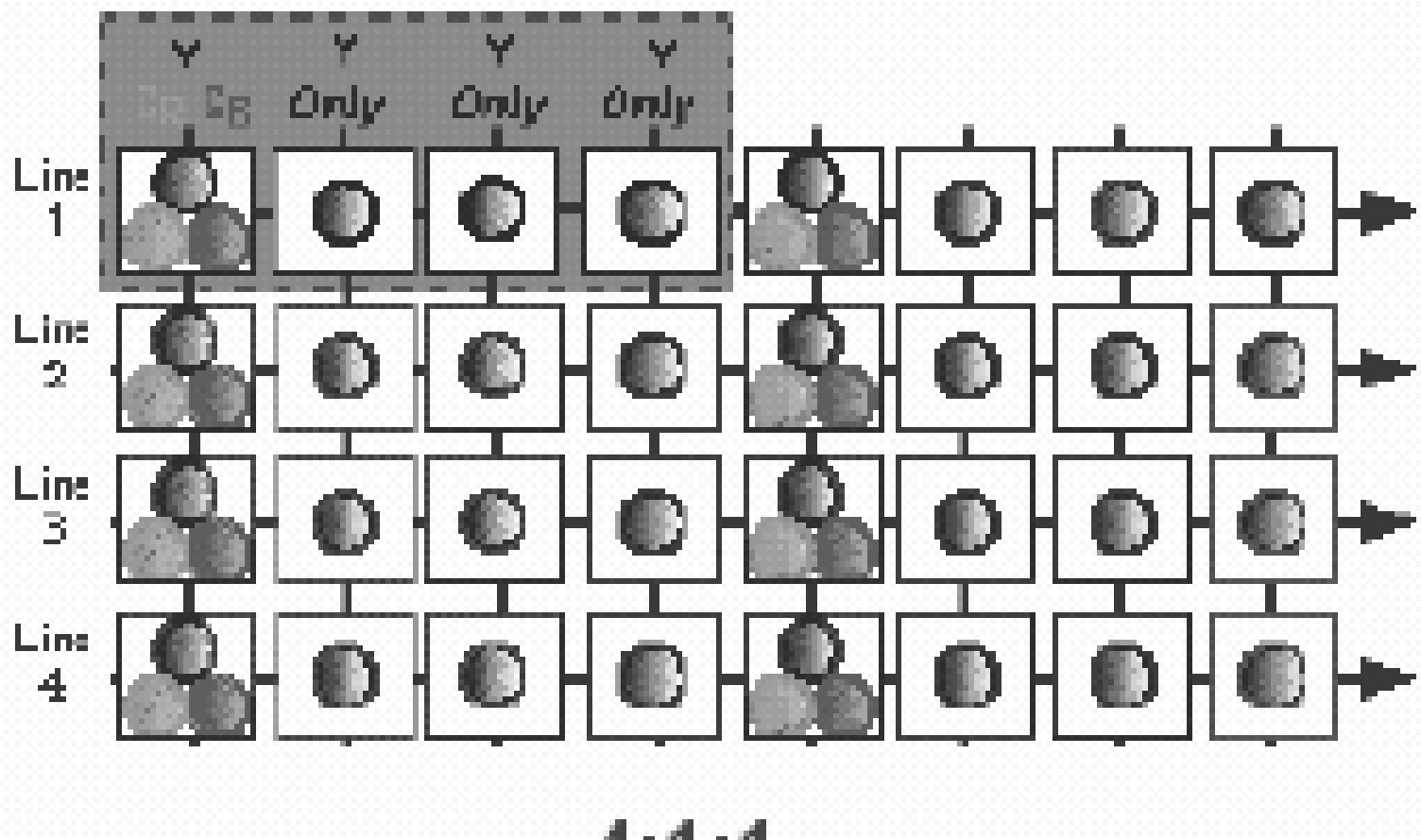
# Scanning Video Standards:

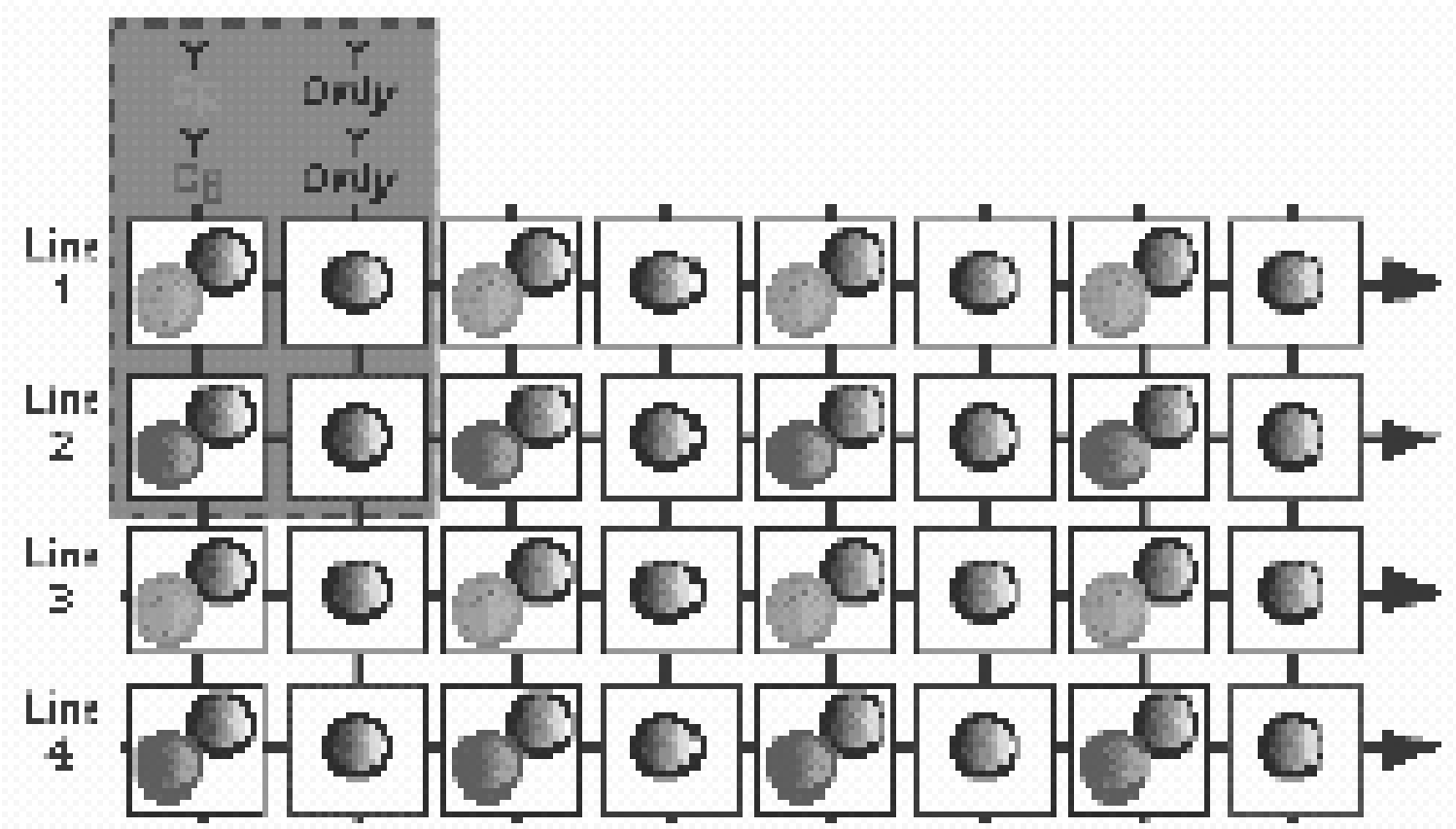
4:4:4 – No sub-sampling

4:2:2, 4:1:1 – horizontal sub-sampling

4:2:0 – Horizontal and Vertical sub-sampling


Y
Y
CR CB
Only
Line 1
Line 2
Line 3
Line 4
4:2:2


Y
Y
Only
Y
Only
Y
Only
Line 1
Line 2
Line 3
Line 4
4:1:1




4:2:0

# Bits/pixel allocation:

4:2:0 and 4:1:1 – For every 4 pixels there are 4samples of luminance and 1 sample each of chrominance resulting in a total of 6 samples.

With 8 bits/sample there are 48 bits per 4 pixels or 12bits/pixel on the average.

4:2:2 – For every 2 pixels there are two samples of luminance and 1 sample each of chrominance resulting in a total of 4 samples.

With 8bits/sample there are 32 bits per 2 pixels or 16 bits/pixel, on the average.

## Standards for Video

| | HDTV | CCIR 601 NTSC | CCIR 601 PAL | CIF | QCIF |
|---|---|---|---|---|---|
| Luminance Resolution | 1920 x 1080 | 720 x 486 | 720 x 576 | 352 x 288 | 176 x 144 |
| Chrominance Resolution | 960 x 540 | 360 x 486 | 360 x 576 | 176 x 144 | 88 x 72 |
| Color Subsampling | 4:2:2 | 4:2:2 | 4:2:2 | 4:2:0 | 4:2:0 |
| Fields/sec | 60 | 60 | 50 | 30 | 30 |
| Aspect Ratio | 16:9 | 4:3 | 4:3 | 4:3 | 4:3 |
| Interlacing | Yes | Yes | Yes | No | No |

CCIR – Consultative Committee for International Radio
CIF – Common Intermediate Format (approximately VHS quality)

# High Definition TV

In 1995, the Advanced Television Systems Committee proposed the **ATSC Digital Television Standard** that covers **HDTV**.

The standard recommends an aspect ratio of 16/9, 1080 vertical lines, 1920 horizontal pixels, and interlaced scan rate of 60. The HDTV format will be a full digital solution.

# References


- R. Steinmetz and K. Nahrstedt, Multimedia Fundamentals, Vol. 1, Prentice-Hall, 2002.
- http://www.kom.e-technik.tu-darmstadt.de/mm-book.