Digital video

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Analog video

	SECAM	PAL	NTSC
Field rate (Hz)	50	50	59,94
Active lines/frame	576	576	480
Pixel aspect	4:3	4:3	4:3
Chromatic components	YΔbΔr	YUV	YIQ
Luminance bandwidth (MHz)	6,0	5,0	4,2
Chrominance bandwidth (MHz)	1,0 (Δb,Δr)	1,3 (U,V)	1,5 (I) 0,5 (Q)
Composite signal bandwidth (MHz)	8,0	8,0	6,0

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0{,}299 & 0{,}587 & 0{,}114 \\ -0{,}147 & -0{,}289 & 0{,}436 \\ 0{,}615 & -0{,}515 & -0{,}100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0{,}299 & 0{,}587 & 0{,}114 \\ 0{,}596 & -0{,}275 & -0{,}321 \\ 0{,}212 & -0{,}523 & 0{,}311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$\Delta b = 3{,}059\ U, \quad \Delta r = -2{,}169\ V$

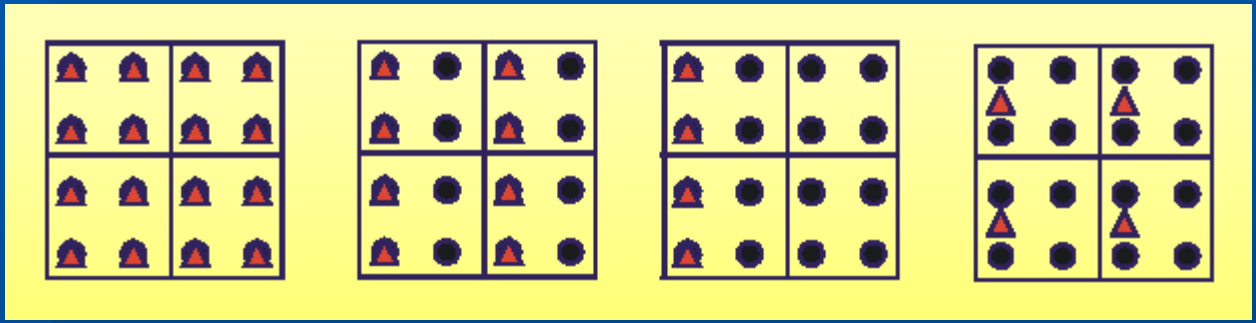
Digital video (1/4)

Recommendation IUT-R BT.601 (May 1982)

- **Chromatic system : Y, Cb, Cr**
- **Sampling frequency Y : 13.5 Mhz**
- **Sampling frequency Cb, Cr : 6.75 Mhz (4:2:2)**
- **Luminance quantization : [16,235]**
- **Chrominance quantization : [-112, 112]**
- **Rectangular quantization**
- **Pixels/line : 720**
- **Interlace factor 2:1**
- **Temporal frequency : 50 Hz ή 60 Hz**
- **Lines/frame : 576 ή 480**

$$Y = 0{,}299\,R + 0{,}587\,G + 0{,}114\,B$$
$$Cb = -0{,}169\,R - 0{,}331\,G + 0{,}500\,B$$
$$Cr = 0{,}500\,R - 0{,}419\,G - 0{,}081\,B$$

Digital video (2/4)



4:4:4

4:2:2

Cb, Cr signals horizontal subsampling by a factor of 2

4:1:1

Cb, Cr signals horizontal subsampling by a factor of 4

4:2:0

Cb, Cr signals horizontal and vertical subsampling by a factor of 2

Digital video (3/4)

CIF : half resolution IUT-R BT.601 4:2:0

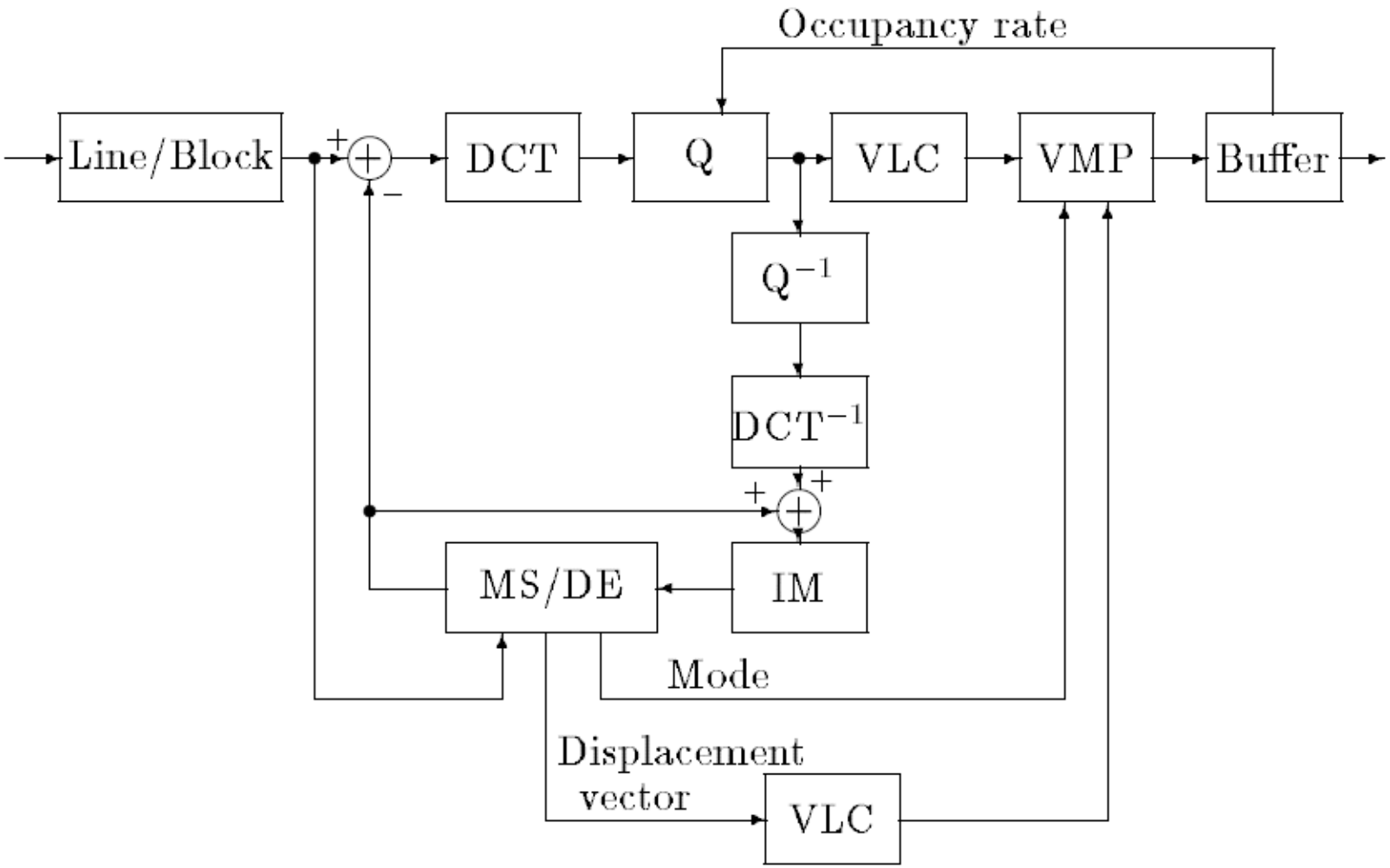
- **Chromatic system : Y, Cb, Cr**
- **Sampling frequency Y : 6.75 Mhz**
- **Pixels/line : 360**
- **Temporal frequency : 25 Hz ή 30 Hz**
- **Lines/frame : 288 ή 240**

QCIF : half resolution CIF

Digital video (4/4)

HDTV	1920 x 1080	ITU-R BT.709, 4:2:0	597 Mbps
Video production MPEG2, 15-50 Mbps	720 x 576	ITU-R BT.601, 4:4:4	249 Mbps
Video production MPEG2, 15-50 Mbps	720 x 576	ITU-R BT.601, 4:2:2	166 Mbps
Video distribution (DVD) MPEG2, 4-8 Mbps	720 x 576	ITU-R BT.601, 4:2:0	124 Mbps
Video distribution (WWW) MPEG1, 1,5 Mbps	352 x 288	CIF 25 Hz, 4:2:0	30 Mbps
Videoconference (ISDN) H.261/H.263, 128-384 kbps	352 x 288	CIF 30 Hz, 4:2:0	36 Mbps
Videophone (H.263, 20-64 kbps)	176 x 144	QCIF 30 Hz, 4:2:0	9 Mbps

MPEG


Occupancy rate
Line/Block
+
−
DCT
Q
VLC
VMP
Buffer
Q^{-1}
DCT^{-1}
+
+
MS/DE
IM
Mode
Displacement
vector
VLC

Digital television

MPEG-2 / MPEG-4 coding

	MPEG-2	MPEG-4
Frequency (Hz)	25,30,50,60 25,30	25,30,50,60
Resolution	1280 × 720 1920 × 1080	1280 × 720 1440 × 1080 1920 × 1080
Pixel aspect	1	1, (4:3)

Digital video (HDV)

- Anti-aliasing filter
- Correction γ (=1/0,45)
- Chromatic system YCbCr
- Chrominance sub-sampling 4:2:0
- MPEG2 coding

	HDV 720p	HDV 1080i
Frequency (Hz)	25,50,30,60	25,30
Resolution	1280 × 720	1440 × 1080
Pixel ratio	1	4:3
Bit rate (Mbits/s)	~18,3	~25

Analog Video Display Interfaces

Component video RGB

Composite Video
chrominance and luminance are mixed into a *single* carrier wave

S-Video
two wires
luminance and
composite chrominance

Video Graphics Array

RGB
640 × 400
70Hz (24MHz)
1280 × 1024 (SXGA)
85Hz (160MHz)
2048 × 1536 (QXGA)
85Hz (388MHz)

Digital Video Display Interfaces

Digital Visual Interface (DVI)
Compatibility VGA

1920 × 1080
60 Hz (165 MHz)
2560 × 1600
60 Hz (340 MHz)

HDMI HIGH-DEFINITION MULTIMEDIA INTERFACE

High-Definition Multimedia Interface (HDMI)
sRGB / YCbCr, 4:4:4 / 4:2:2

1920 × 1080
60 Hz (165 MHz)
2560 × 1600
60 Hz (340 MHz)
5120 x 2880
60 Hz (600 MHz)

DisplayPort

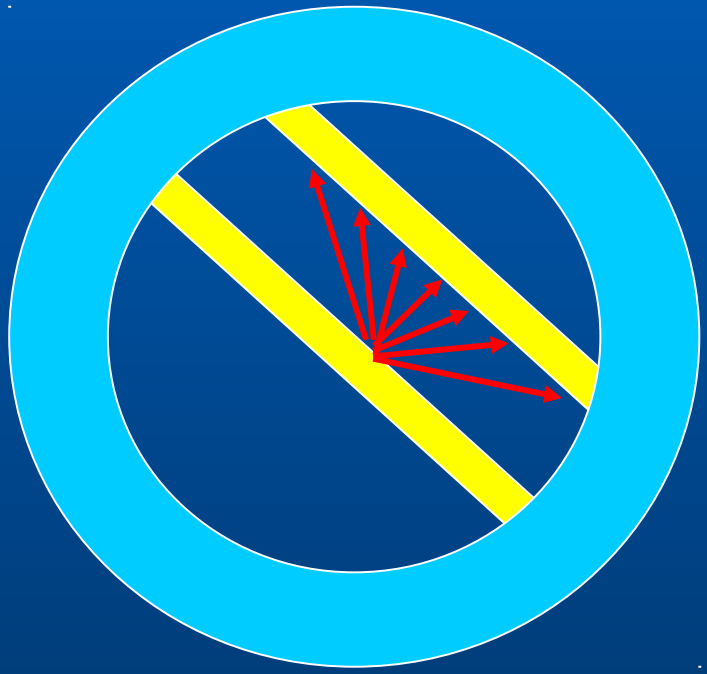
2-D motion

Optical flow / intensity conservation law
Translational motion / diffuse refection

$$I(x,y,t) \approx I(x-\Delta x, y-\Delta y, t-\Delta t)$$

$$I_x(x,y,t)u + I_y(x,y,t)v + I_t(x,y,t) \approx 0$$

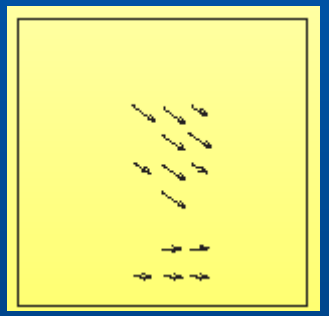
Only one component for a 2-D vector



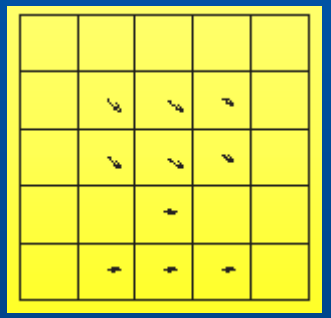
Aperture problem

2-D motion field

A priori knowledge : velocity field coherence

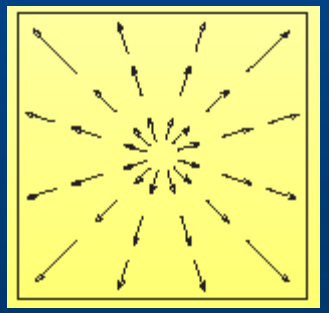


«smooth»



«block»

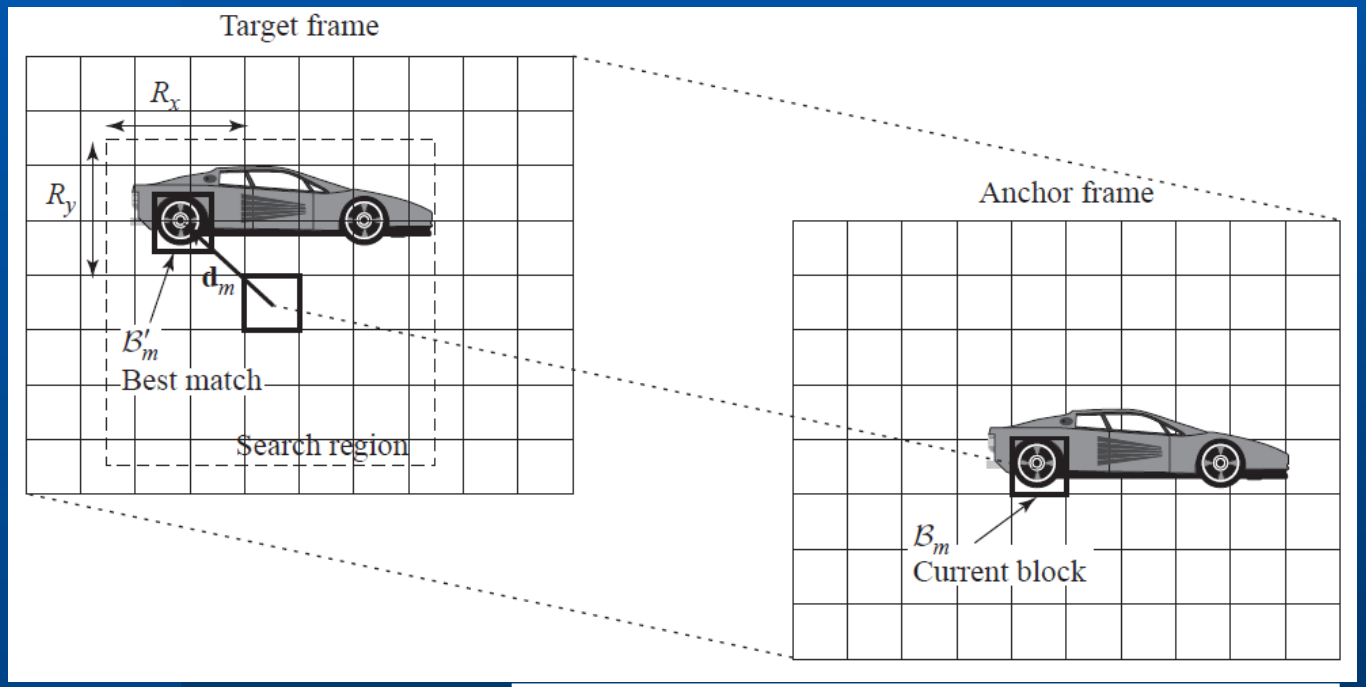
«regions»



«parametric»

Block matching

- Translational motion
- Displaced frame difference minimization



Yao Wang, Video Processing and Communication