Video

Philco H3407C (circa 1958)

Never before have I witnessed compressed into a single device so much ingenuity, so much brain power, so much development, and such phenomenal results

David Sarnoff

Topics

Film and television

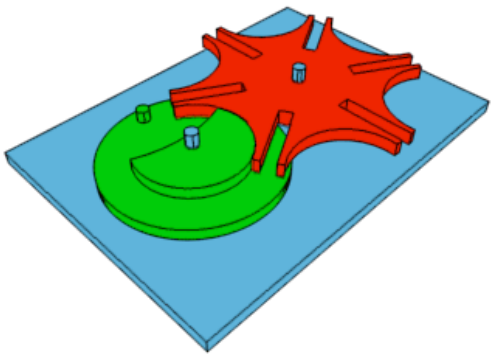
Frequency modulation

Color television (NTSC)

HDTV

MPEG-2

Motion Picture Camera



Motion Picture Formats

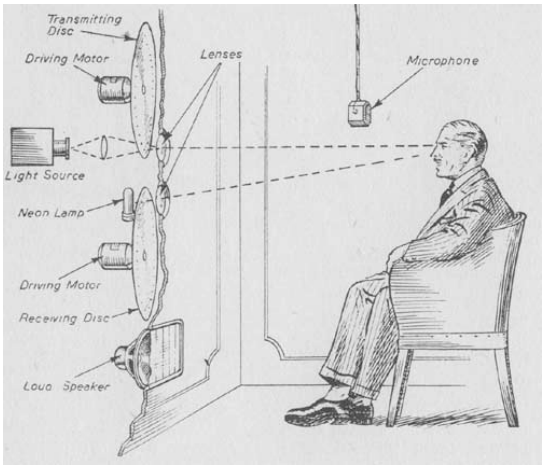
Television	**4:3**
HDTV	**16:9**
35mm	**3:2**
Panavision	**2.35:1 (2:1 anamorphic)**
Vistavision	**2:35:1 (1.5:1 anamorphic)**

Television is 30 Hz

Film is 24 Hz

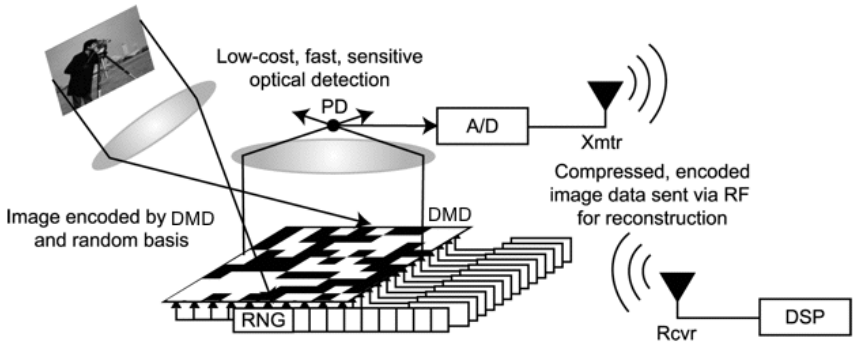
Difficult to convert frame rates (3:2 pulldown)

Mechanical Television (Nipkow Disk)



Mechanical Television, Concept by Paul Nipkow, 1884
Invented and deployed by John Baird in 1933

Single Pixel Camera - Compressed Sensing



http://www.dsp.ece.rice.edu/cs/cscamera/

All-Electronic Television

Challenge was to develop the camera

Philo Farnsworth – solo inventor

Camera: Image Dissector

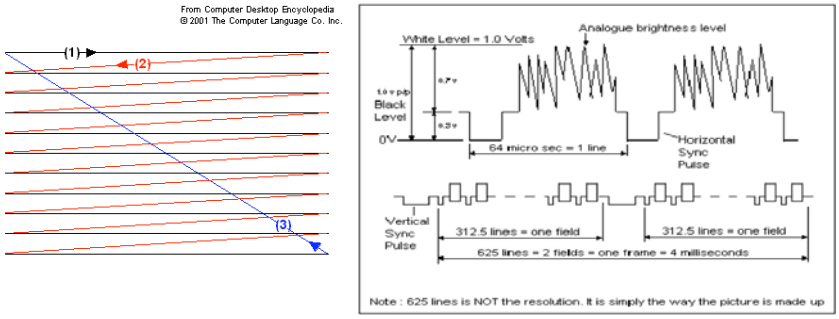
Vladimir Zworykin – RCA industrial research

Receiver: Kinescope (1929)

Camera: Iconoscope (1931), Orthicon (1933)

1933 World's Fair demonstration – 343 lines, 60 fields

Raster Scan



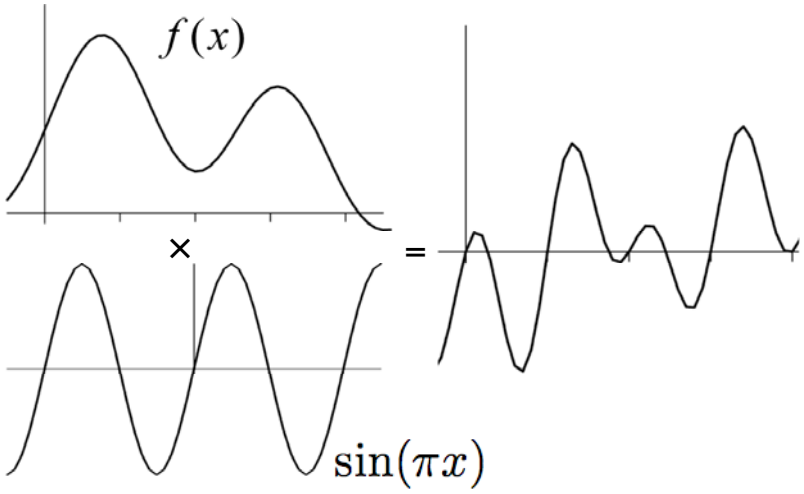
2D to 1D: Discrete in y, continuous in x

NTSC standard: 525 lines @ 30Hz, interlaced

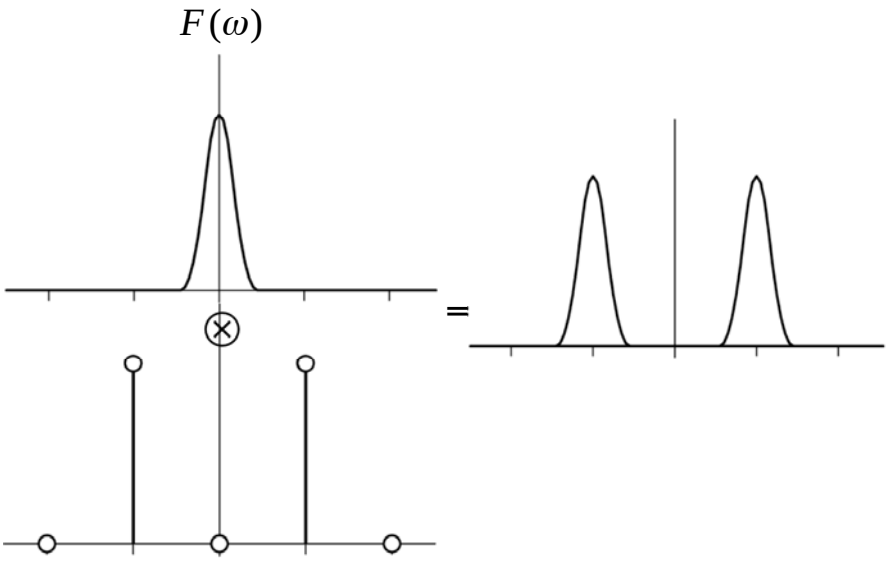
For smooth animation, synchonize vertical refresh with swapbuffers

Animate on fields

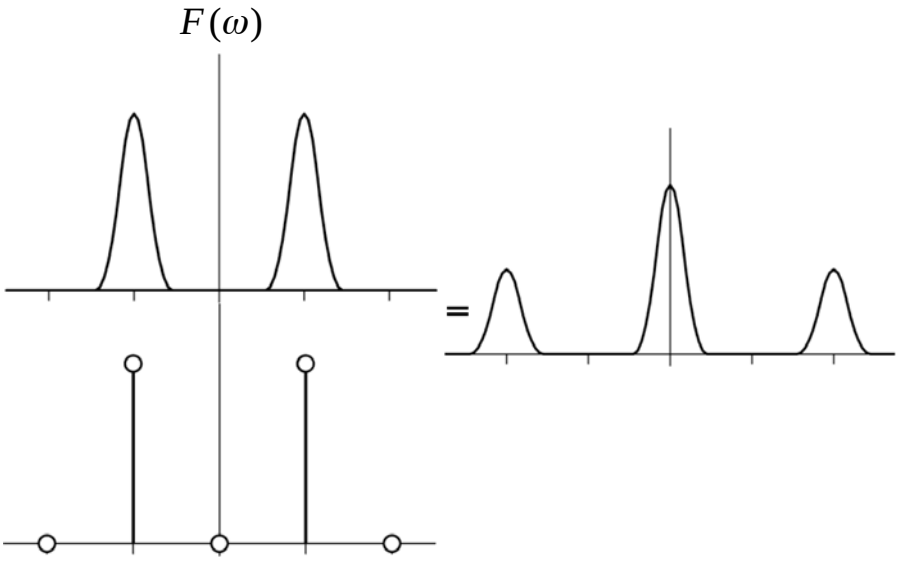
Amplitude Modulation: Time Domain



Amplitude Modulation - Freq. Domain



Demodulation - Freq. Domain



Spectrum Allocation

Channels are separated by 6 Mhz, 4.2Mz for signal

- **Limits spatial resolution**

VHF

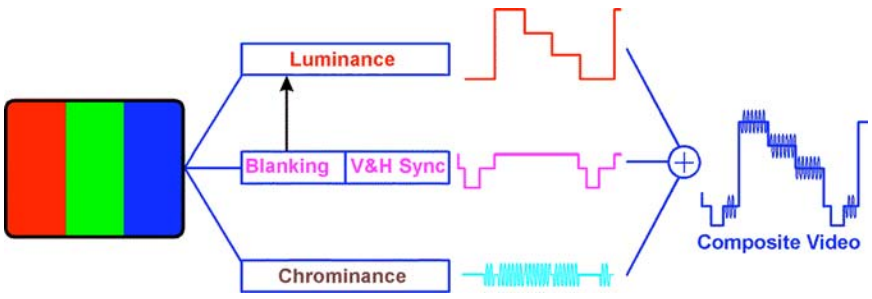
54-72 Mhz - Channels 2-4

76-88 Mhz - Channels 5-6

88-108 Mhz - FM Radio

124-216 Mhz - Channels 7-13

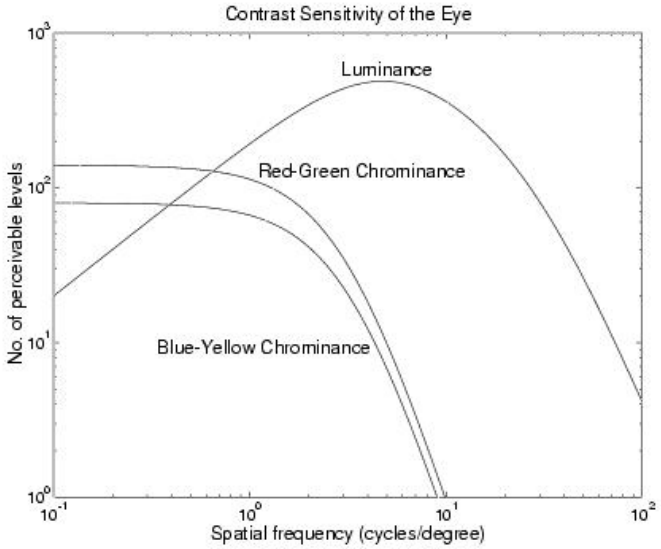
Color Television



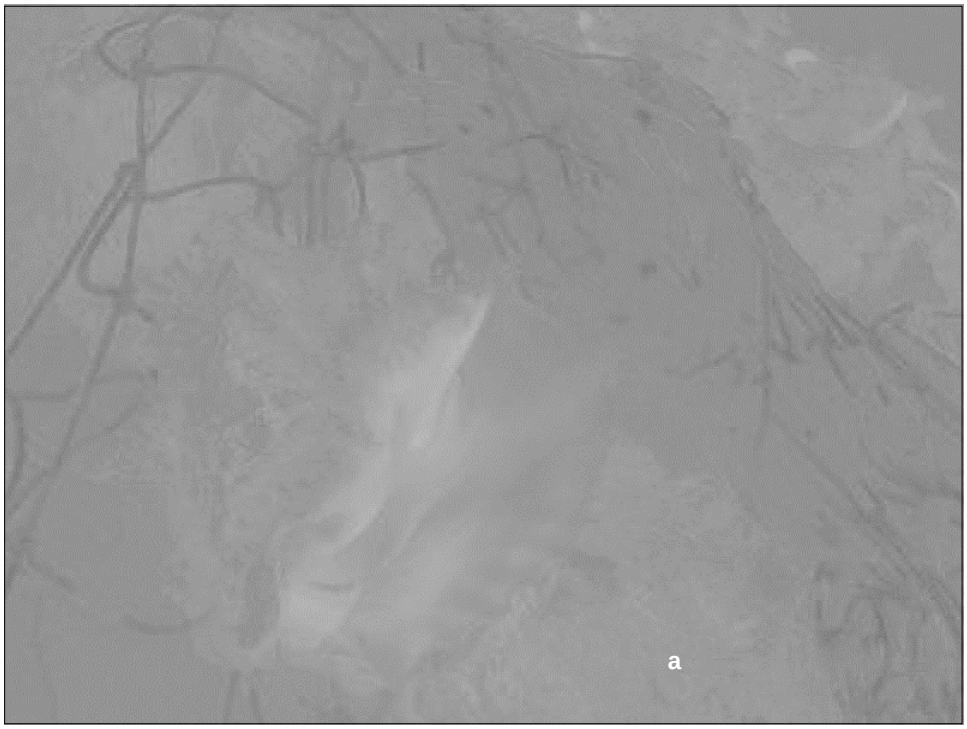
Separate signal into

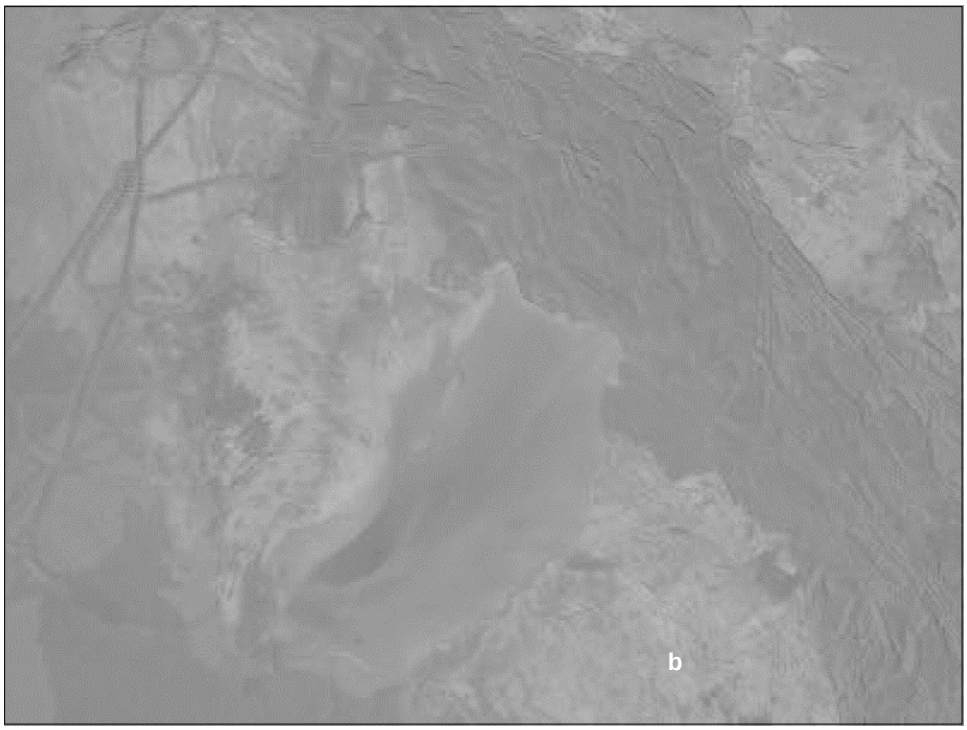
- **Luminance (Y)**
- **Chrominance (Y-R, Y-G)**

Spatial Frequency Response to Color



Lightness


a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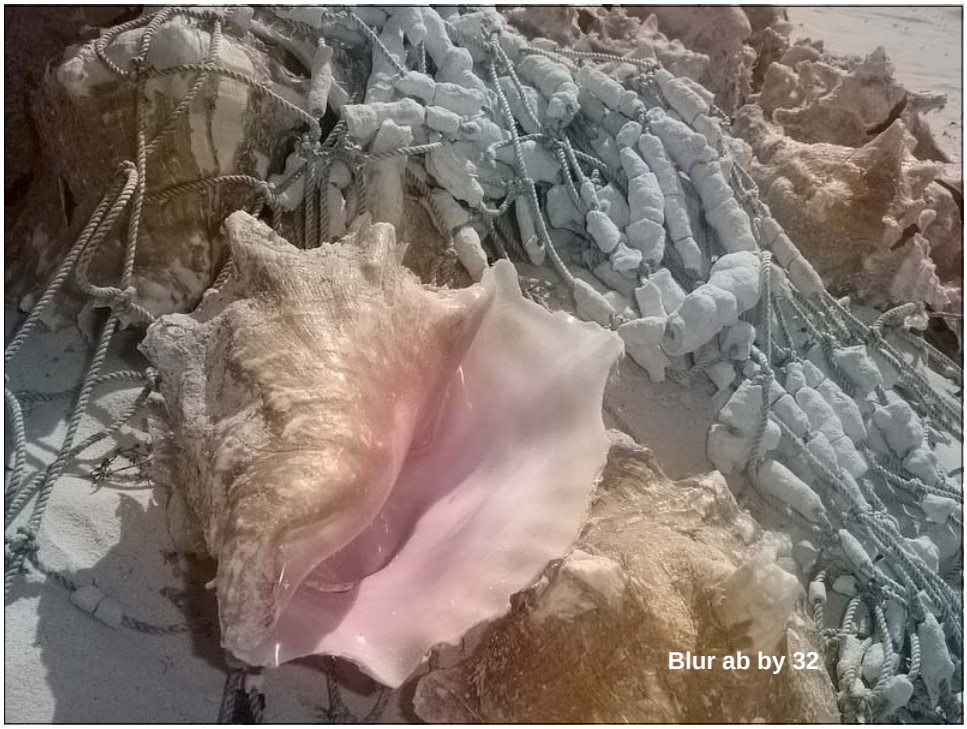
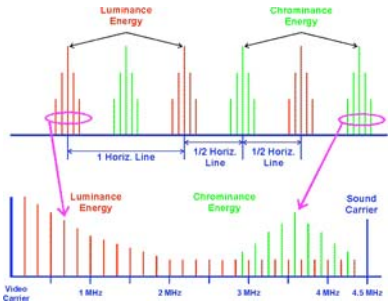

Blur ab by 32

Composite Video

$$V(t) = Y(t) + (Y(t) - R(t))\cos(\omega_c t) + (Y(t) - G(t))\sin(\omega_c t)$$

Color subcarrier

$$f_c = 3.58\text{Mhz}$$



Features:

- **Signal compatible with black and white**
- **(Y-R) and (Y-G) has less bandwidth than**
- **Note: May get color aliasing!**

Background to HDTV

Situation 1987

- **Land-Mobile wanted unused broadcast spectrum; FCC decides in their favor**
- **Broadcasters invent HDTV scenario**
- **NHK demonstration of analog HDTV**
  - **Analog 1192:60**
  - **Satellite broadcast**
  - **Used 2 channels (8 Mhz)**
- **Reaction**
  - **Can't cede the technology to the Japanese**
  - **Can't go with an analog standard**

ATSC

FCC Advanced Television Standards Committee

Key competitors:

- **Zenith and Bell Labs: 8-VSB and progressive**
- **General Instruments and MIT: digital (mpeg)**
- **Philips, Sarnoff (RCA), Thomson**

1993 Grand Alliance formed

1996 Telecommunications Act

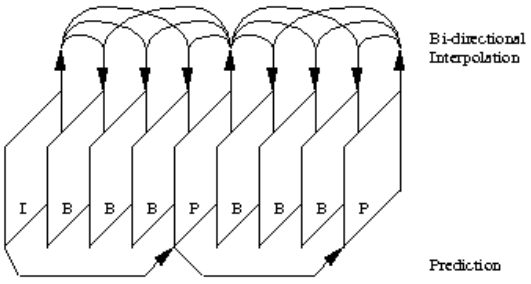
- **2002: commercial stations must begin digital broadcasts**
- **2006: must eliminate analog (Balanced budget Act of 1997 delays this until 85% of TVs are digital)**

18(!) ATSC Formats

Name	Resolution (Pixels)	Progressive (Hertz)	Interlaced (Hertz)
4:3 aspect			
	640 x 480	60/30/24	30
	704 x 480	60/30/24	30
16:9 aspect			
SDTV	704 x 480	60/30/24	30
HDTV A	1280 x 720	60/30/24	
HDTV B	1920 x 1080	30/24	30

Notes: Fox, ABC, ESPN use 720p, others 1080i

MPEG-2

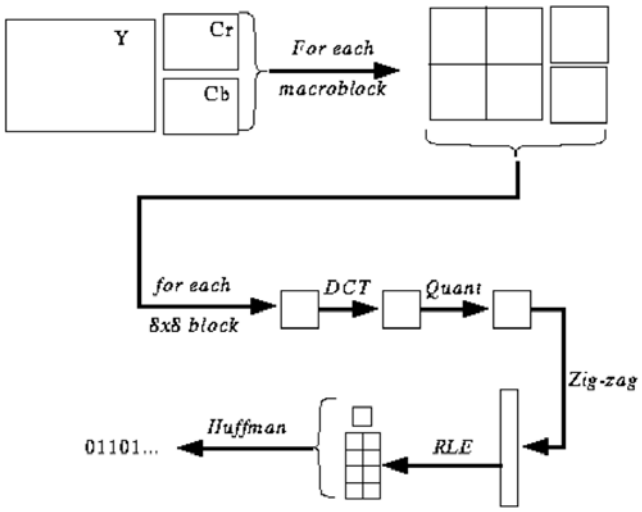


Intra-pictures (I) - compressed as a single frame

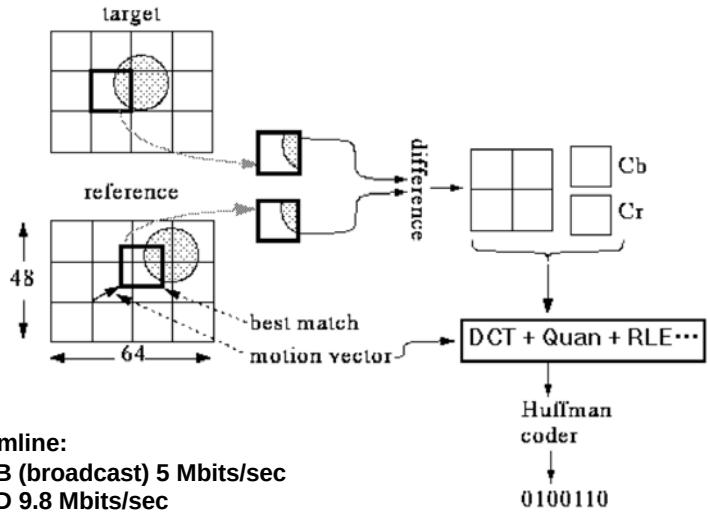
Predicted-pictures (P) - compressed from previous P

Bidirectional-pictures (B) - compressed from pairs of I/P

JPEG Compression (I-Frames)



Motion Prediction (P and B Frames)



Bottomline:

DVB (broadcast) 5 Mbits/sec

DVD 9.8 Mbits/sec

Summary

HDTV just emerging

- **HDTV broadcasts**
- **HD DVD formats (blu-ray)**

Video on the internet is a hot topic

- **youtube and the video ipod**

Television uses many clever techniques

- **Elaborate compression system based on motion prediction**
- **Spatial frequency response of human vision**