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Multimedia Signal Processing

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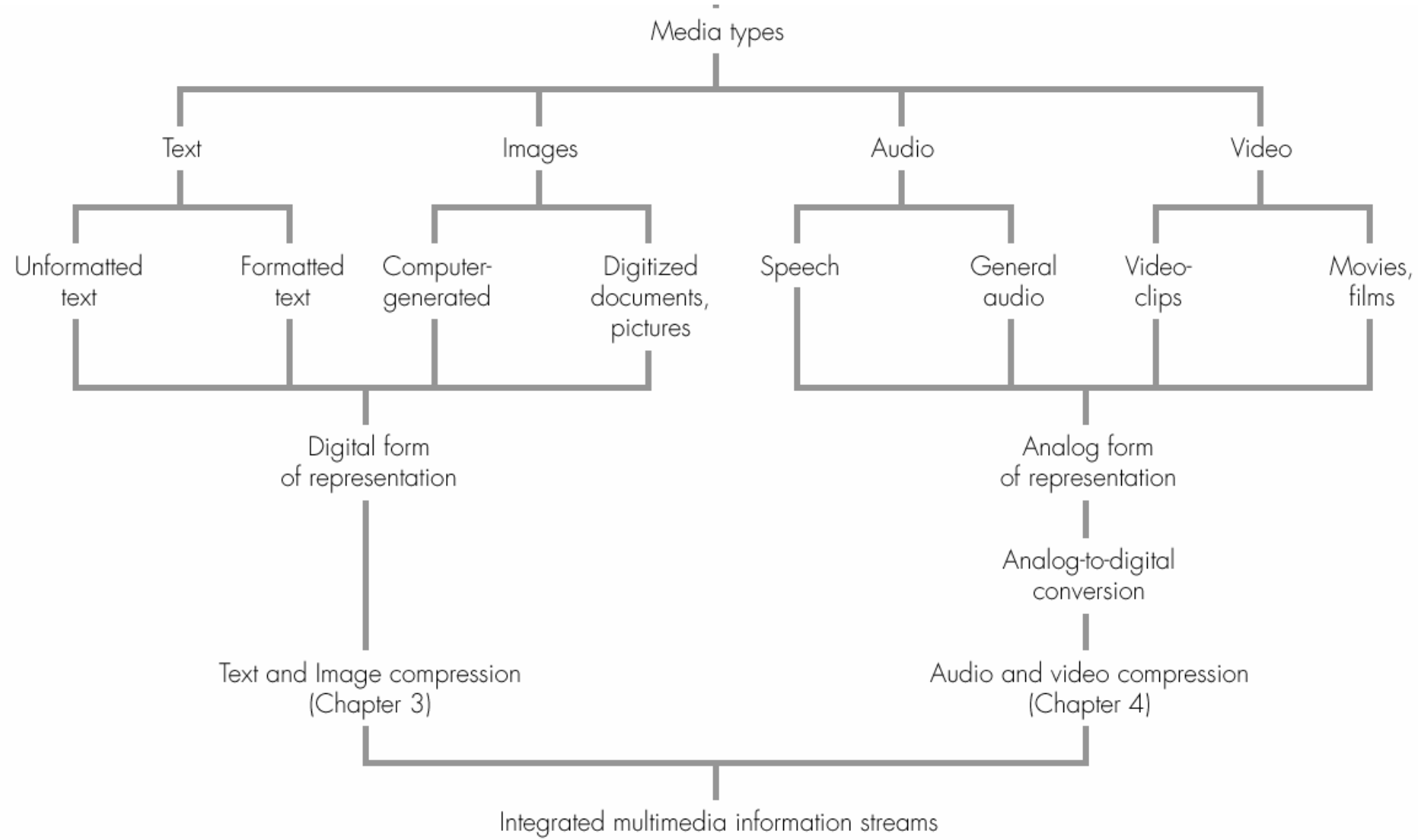
September 4, 2006

What is Multimedia?



Multimedia Technologies

- *Technologies for generating, processing, storing, and transmitting MM that revolutionized the way we live, work, learn,and communicate*
  - MM-based Consumer Electronic Products
  - Personal Communications
  - Entertainment (home, public, tv, games)
  - Science
  - Medical/Health Applications
  - Video Surveillance and Monitoring
  - Military Applications
  - Education/Training
  - Arts/Museums/Libraries
  - Shopping and Retailing
- Impact of MM Technology (social, economic, political, cultural, psychological)

What is Multimedia Signal Processing?

- The processing of multiple signal sources (i.e., text, speech, music, image, video, graphics,etc) and the exploitation of their interaction
- MMSP opens up opportunities for signal processing research that falls in-between the domains of traditional areas
- MMSP brings together the communities of SP, Comm., Computer, and Network engineers, Comp. Scientists, Psychologists,…

Multimedia Signal Processing

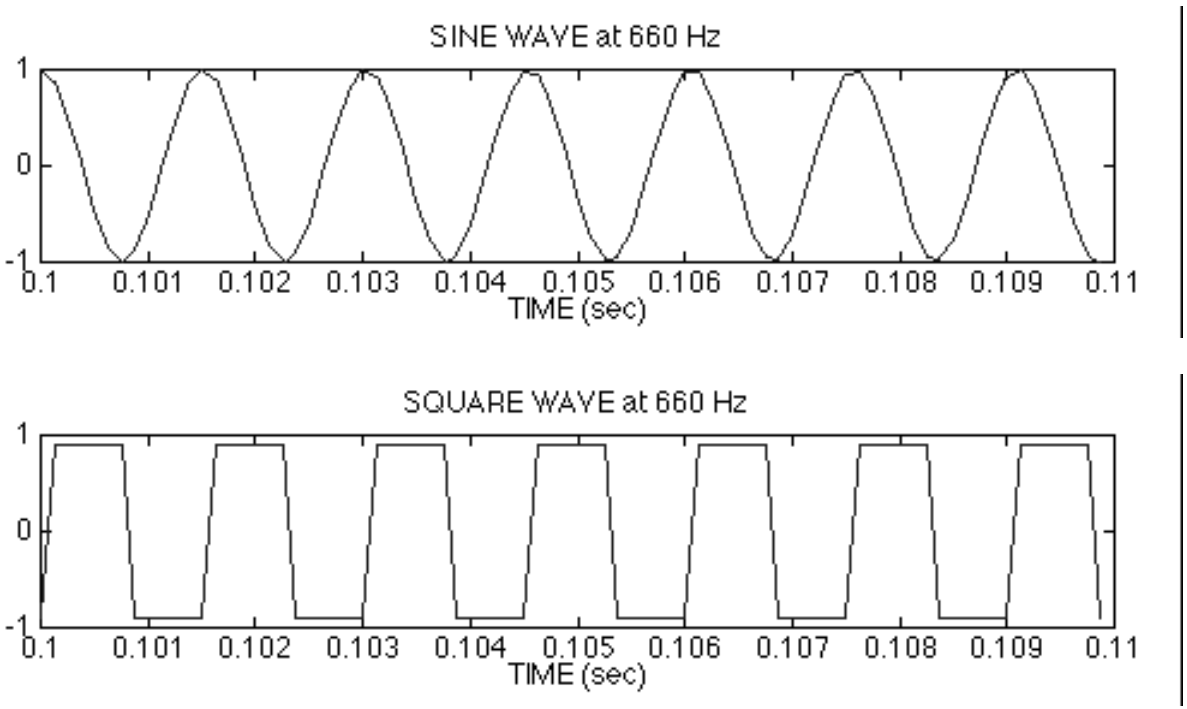
- Representation
- Filtering, Enhancement, Restoration
- Compression
- “Preparation” for Transmission
- Analysis (Content Extraction, Representation)
- Indexing, Retrieval
- Speech Recognition (audio/video only, audio-visual)
- Person Recognition (identification, authentication)
- Data Hiding, Watermarking
- Human-Computer Interfaces

1-2-3 Dimensional Signals

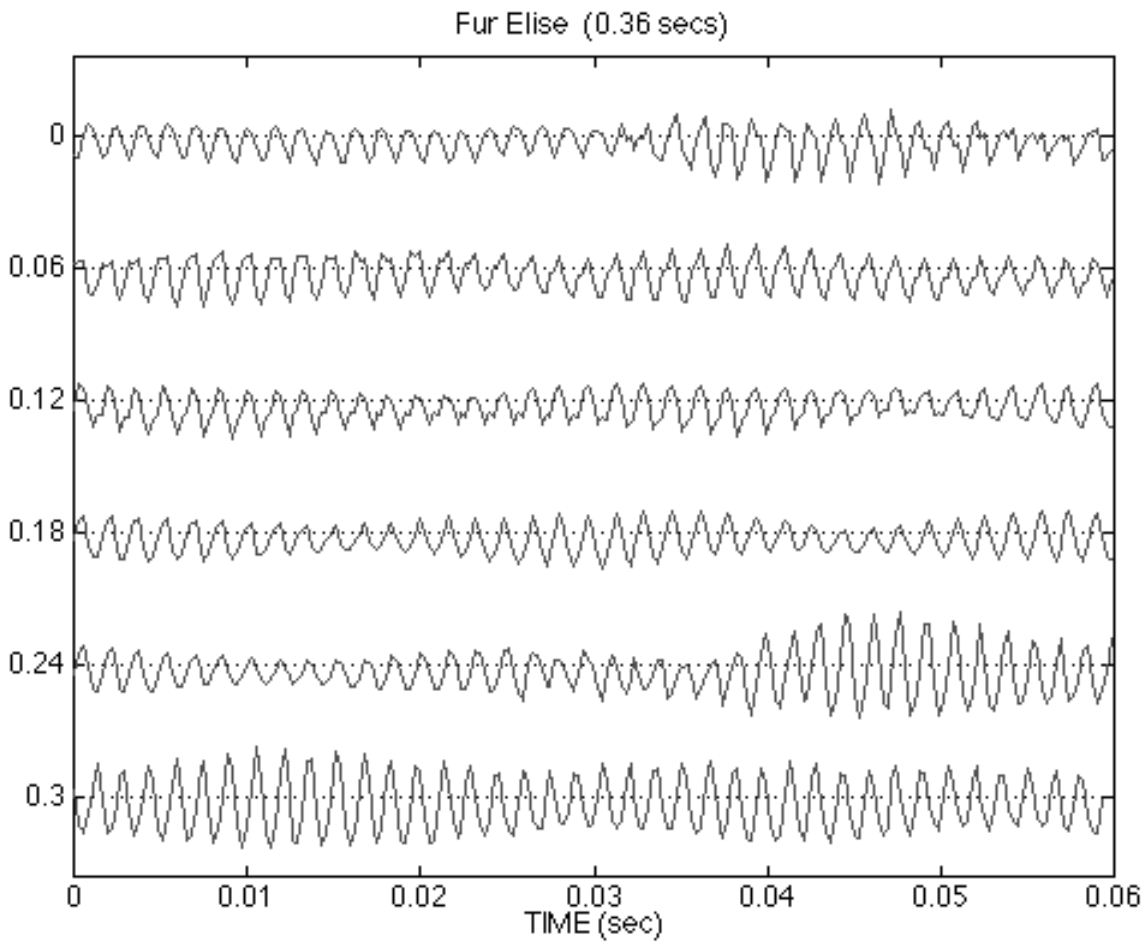
- 1 D: tones, speech, audio, biomedical, remote sensing, etc
- 2 D: text, images, remote sensing, etc
- 3 D: video, stereo, etc

- Two main representations
  - Time or spatial domain
  - Frequency domain

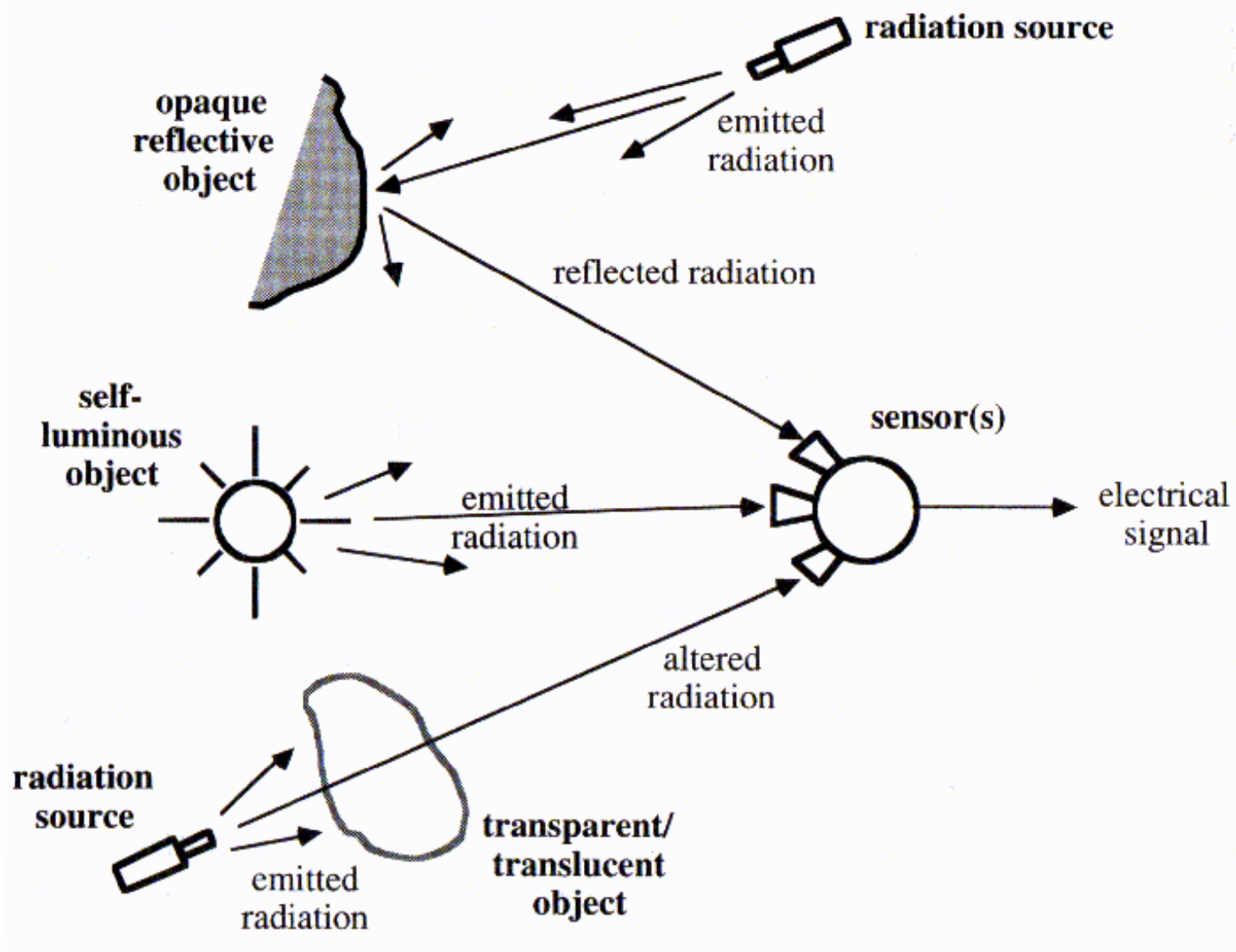
Tones


SINE WAVE at 660 Hz
1
0
-1
0.1
0.101
0.102
0.103
0.104
0.105
0.106
0.107
0.108
0.109
0.11
TIME (sec)
SQUARE WAVE at 660 Hz
1
0
-1
0.1
0.101
0.102
0.103
0.104
0.105
0.106
0.107
0.108
0.109
0.11
TIME (sec)

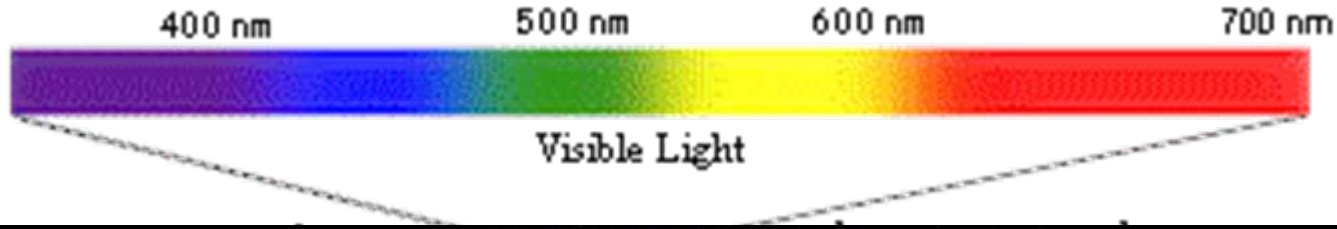
Piano piece

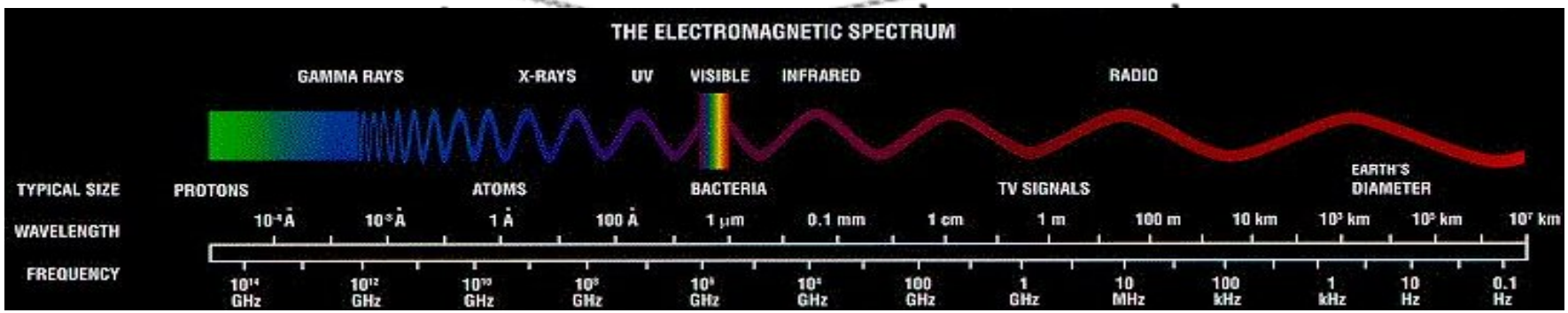

Fur Elise (0.36 secs)
0
0.06
0.12
0.18
0.24
0.3
0
0.01
0.02
0.03
0.04
0.05
0.06
TIME (sec)

Recording an Image

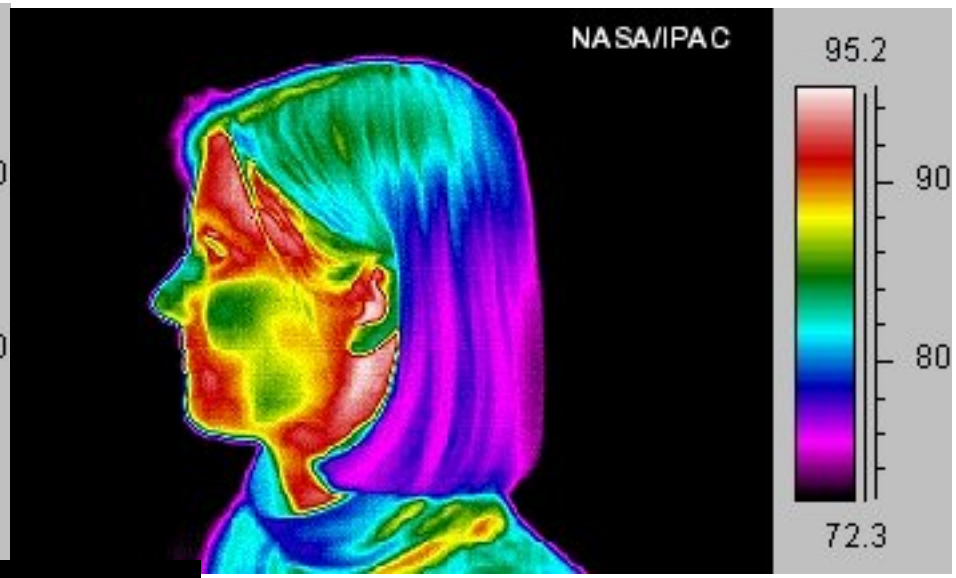


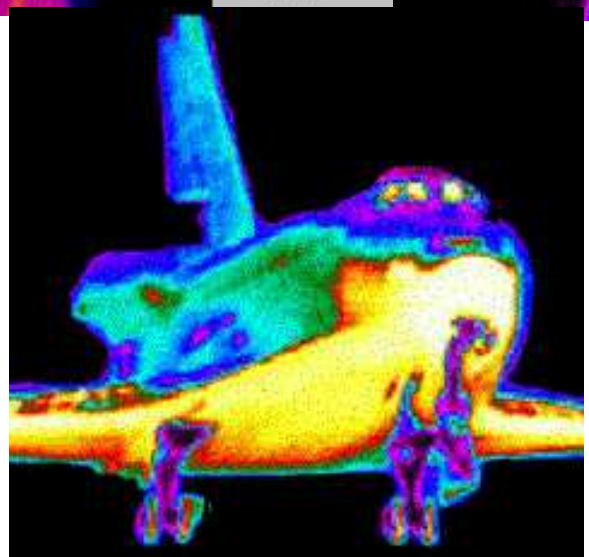
The Electromagnetic Spectrum





Infrared Images





http://www.ipac.caltech.edu/Outreach/Edu/imgvid.html

X-ray images

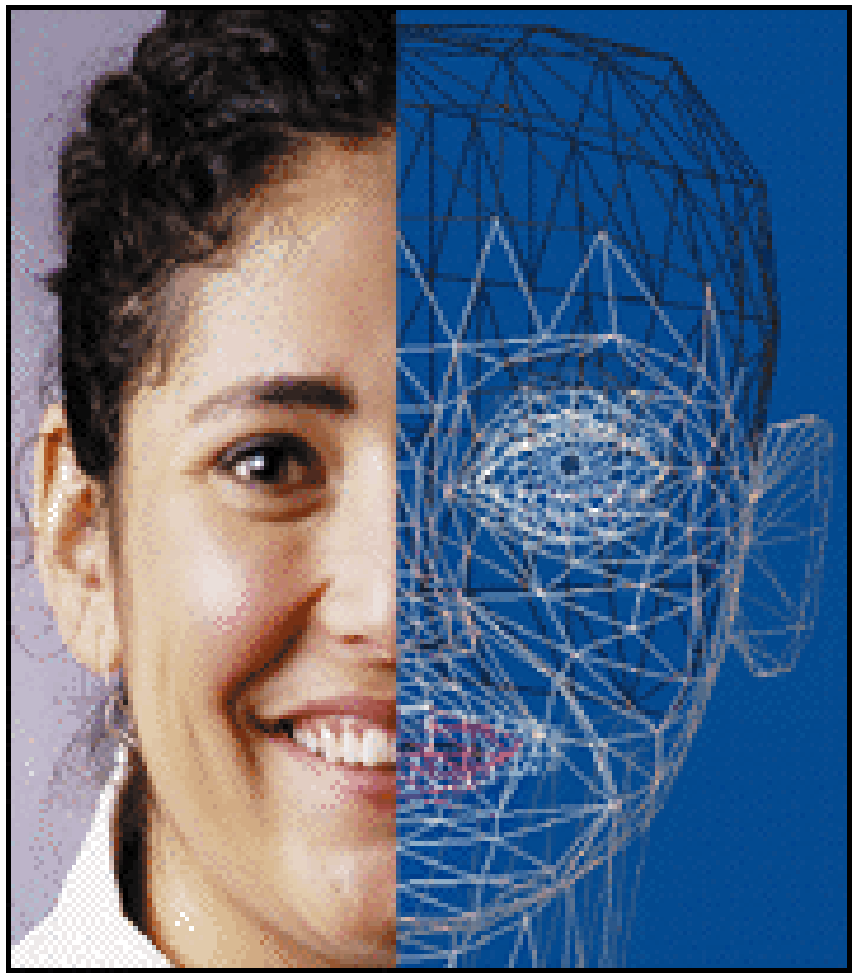
http://www.eee.ntu.ac.uk/research/vision/asobania/

http://www.msoe.edu/eecs/be/srdesign/biodata/images/xray/xray.html

Ultrasound image

http://www.parenthood.com/us.html

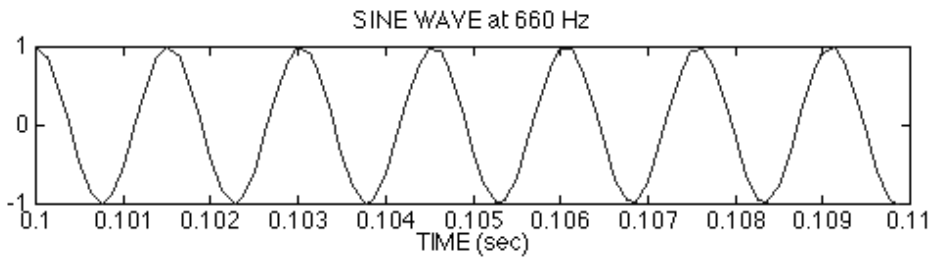
Computer Graphics

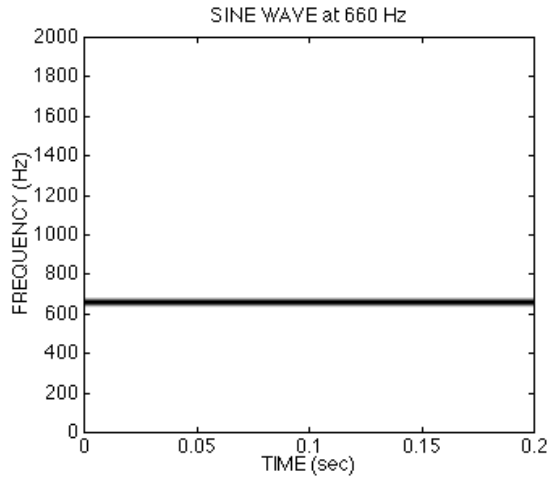


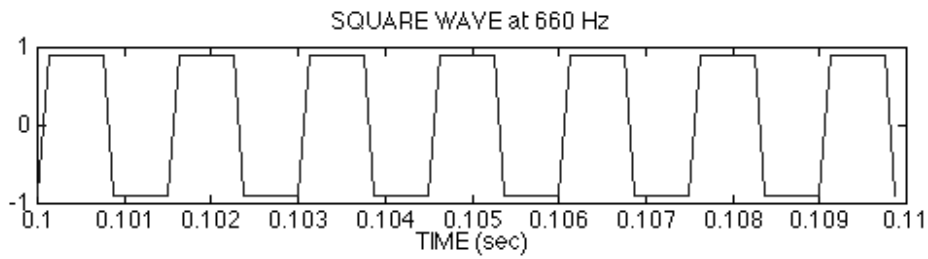
Fourier Domain Representation of Signals

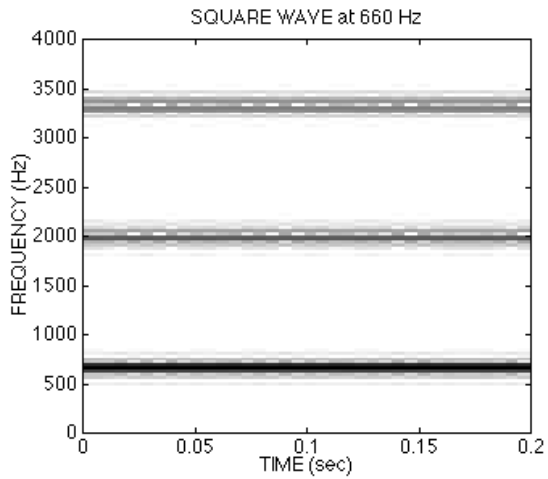
- Every signal can be decomposed into basic tones (complex exponentials)
- The Fourier Transform (FT) provides us with such a decomposition
- The Discrete Fourier Transform (DFT) maps any discrete signal into its discrete frequency representation
- There exist fast algorithms for computing the DFT called Fast Fourier Transforms (FFTs)

Time and Frequency Representation of Signals

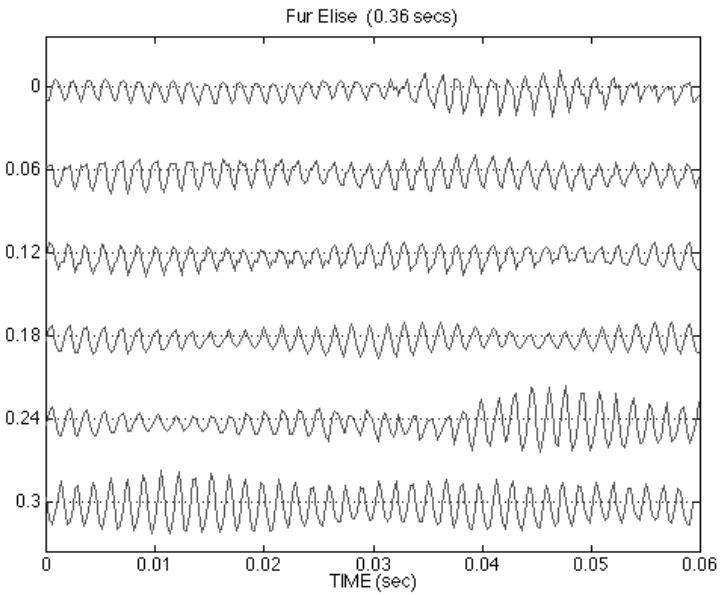


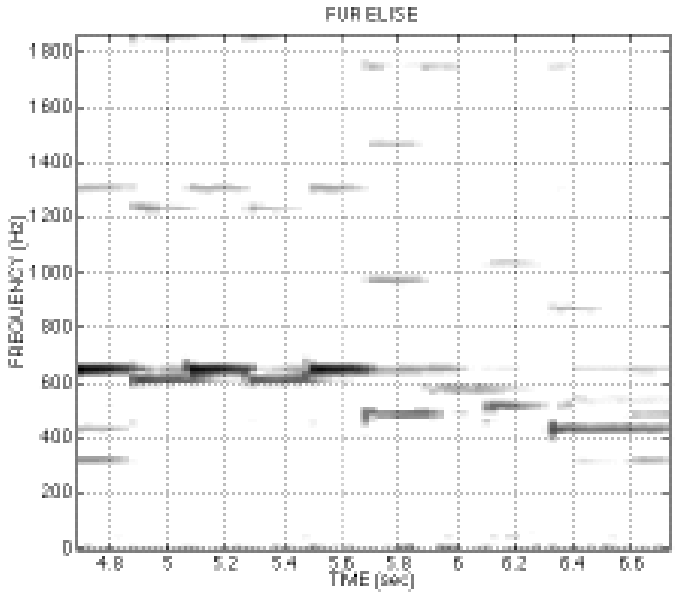




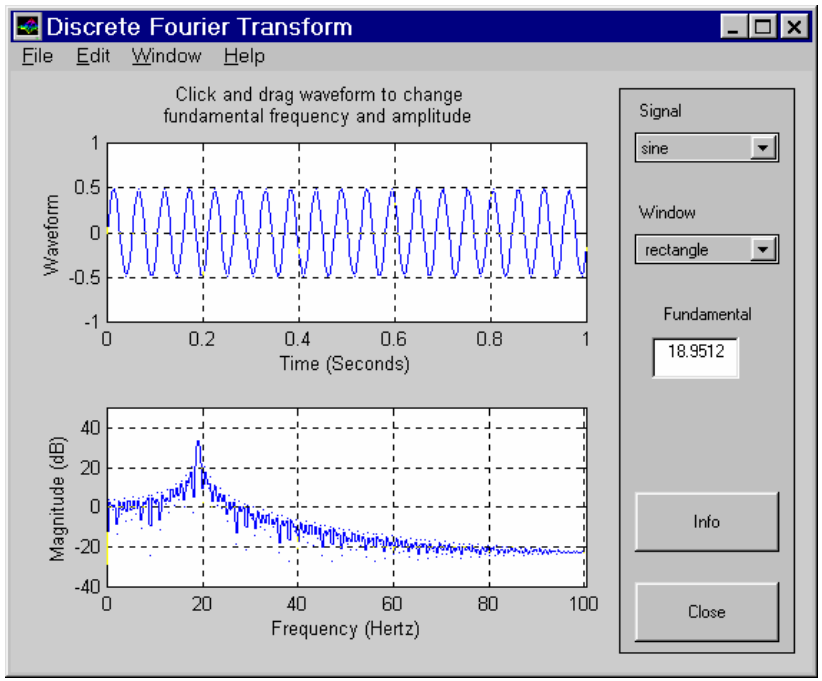


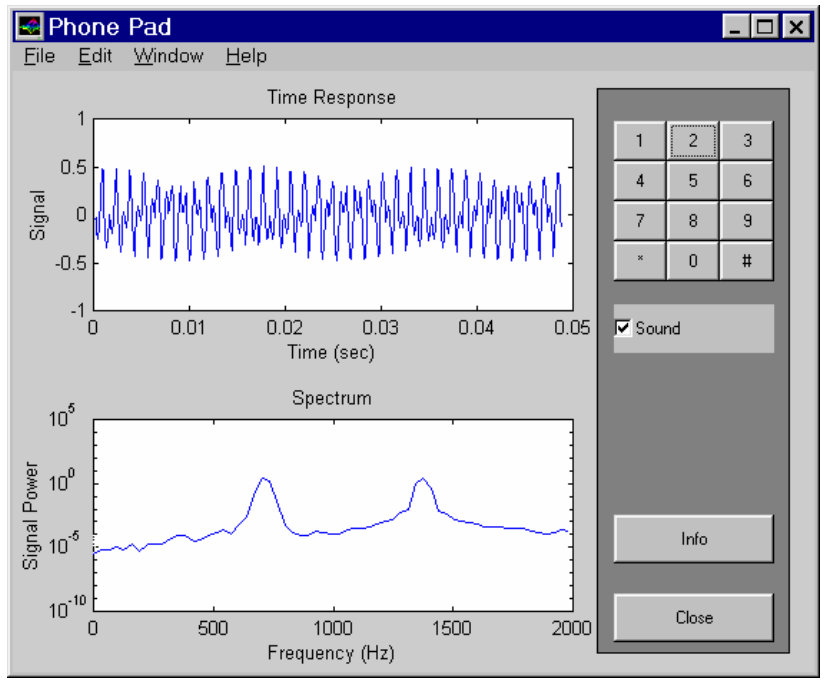
Time and Frequency Representation of Signals





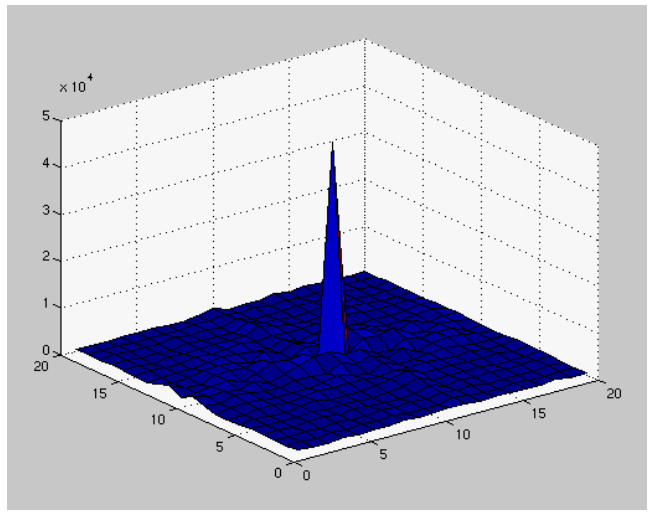
Time and Frequency Representation of Signals

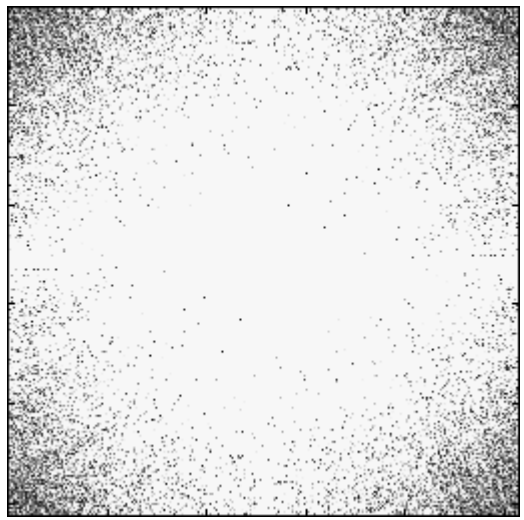




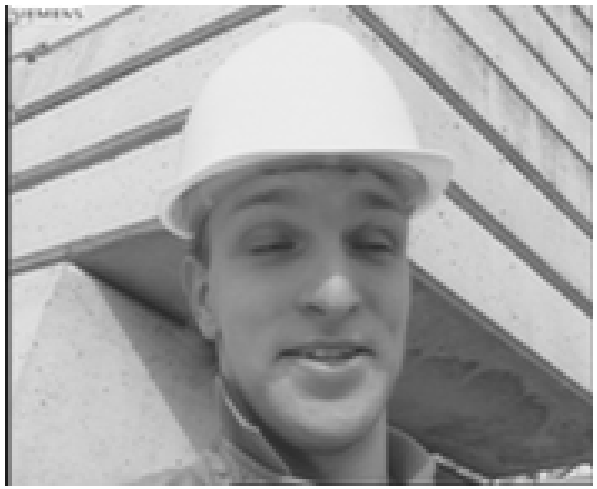
Spatial and Frequency Representation of a Signal

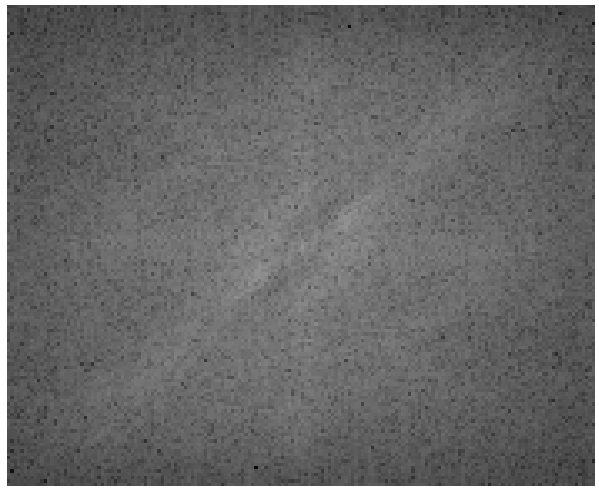
DFT





Spatio-temporal and frequency representation





Continuous and discrete signals

- Most signals of interest are continuous
- In most cases we are interested in processing analog signals digitally, i.e., using computers

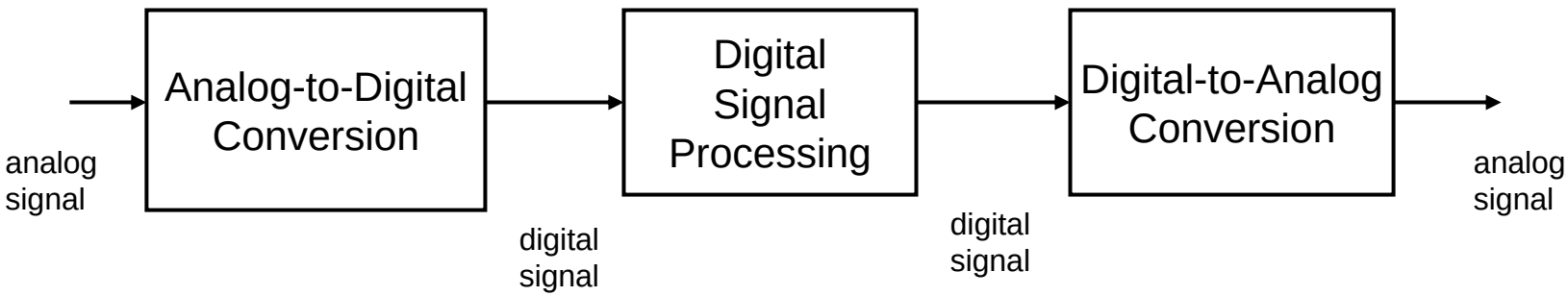
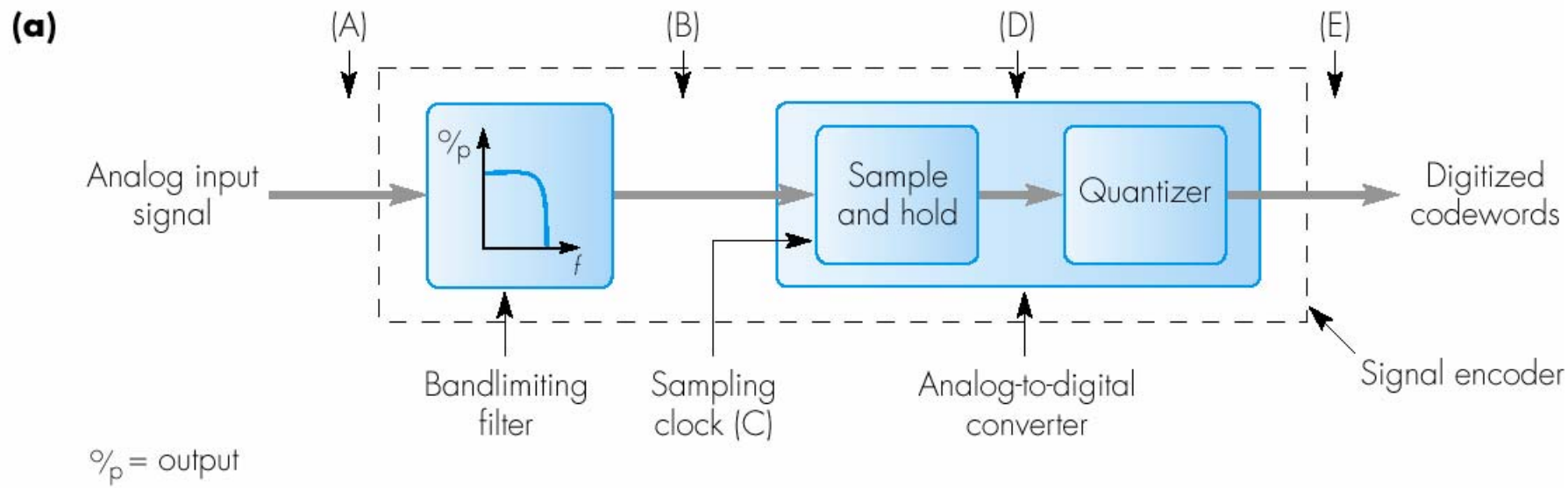
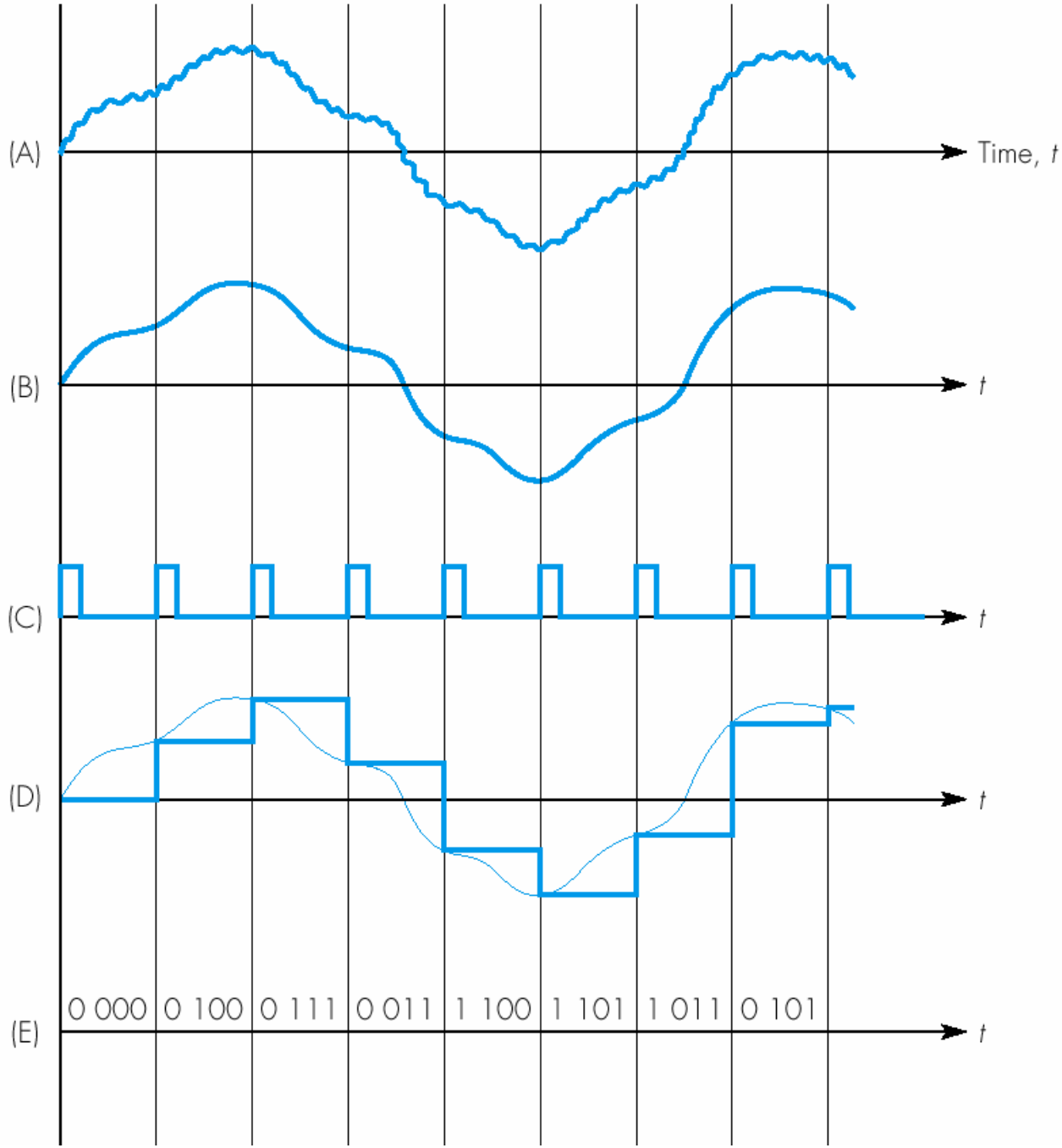
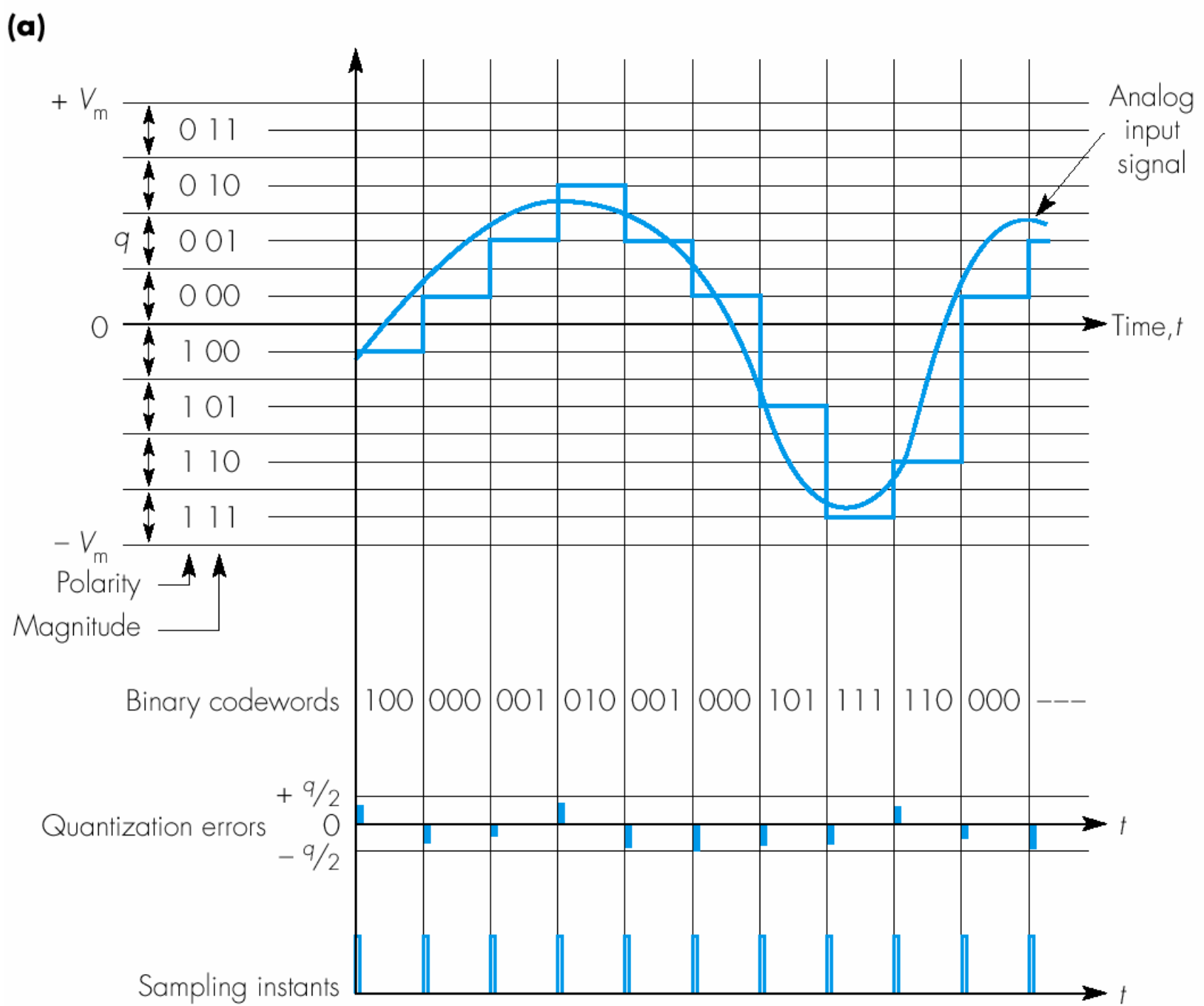


Figure 2.2 Signal encoder design: (a) circuit components; (b) associated waveform set.



(b)

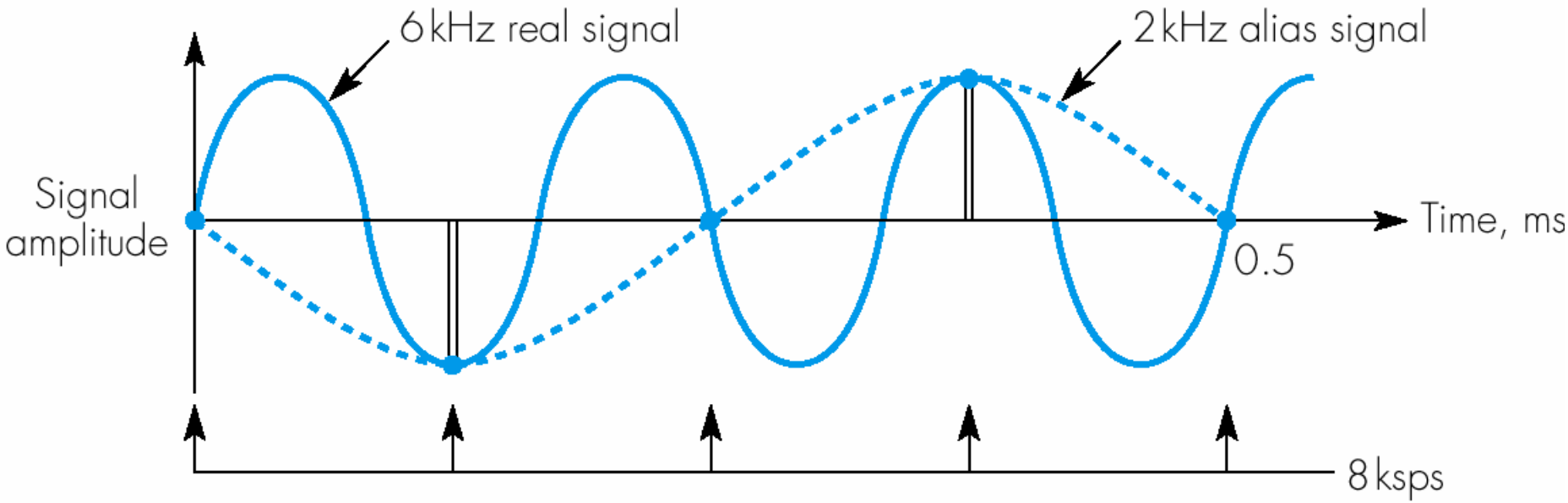


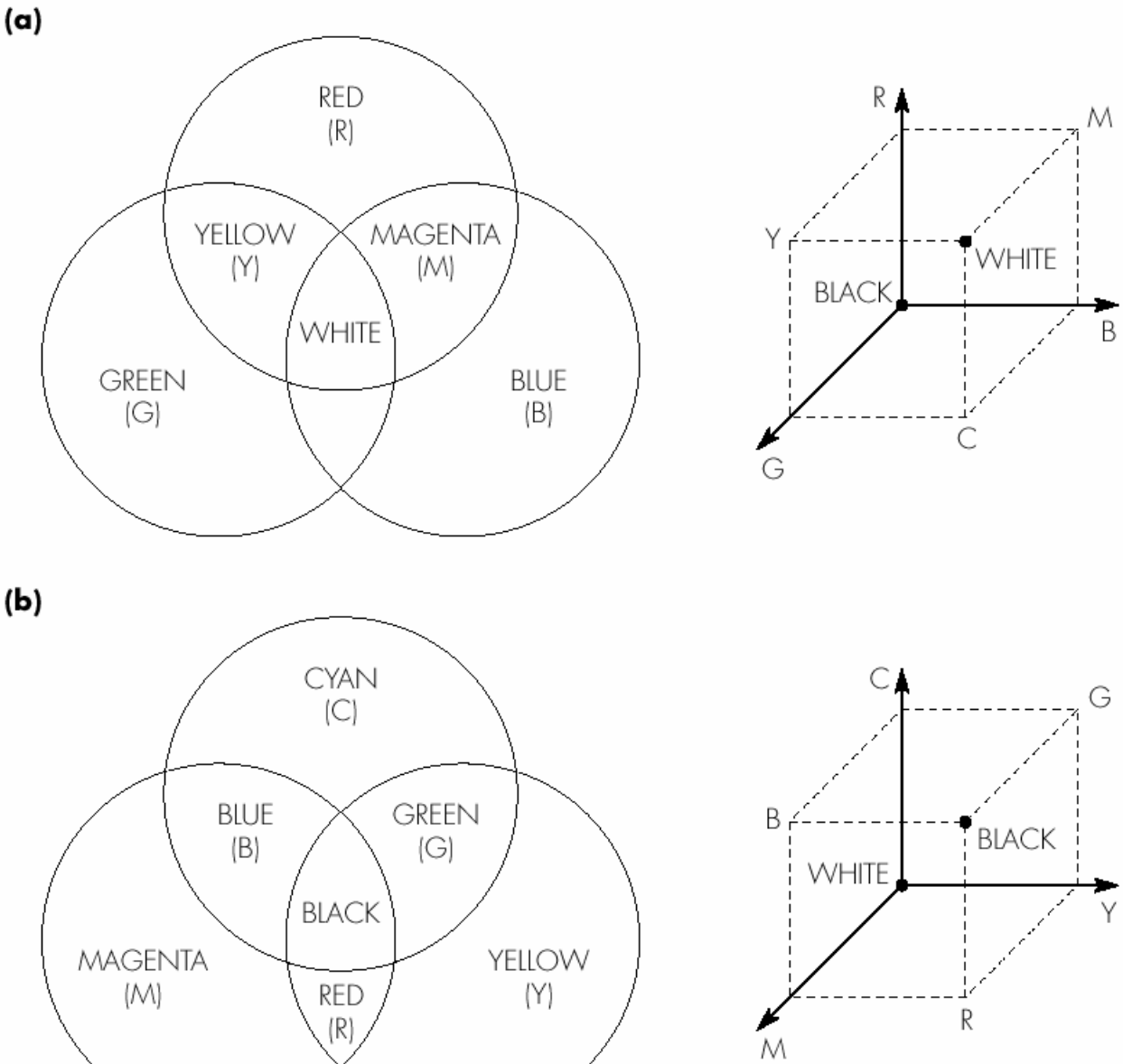

(a)
+ V_m
0 11
0 10
q
0 01
0 00
0
1 00
1 01
1 10
1 11
– V_m
Polarity
Magnitude
Analog input signal
Time, t
Binary codewords
100 000 001 010 001 000 101 111 110 000 ---
Quantization errors
+ q/2
0
– q/2
t
Sampling instants
t

Sampling Theorem

For a bandlimited signal in order to be able to reconstruct it from its samples, they have to be taken at a frequency at least twice the highest frequency in the signal (Nyquist rate)

Aliasing due to undersampling



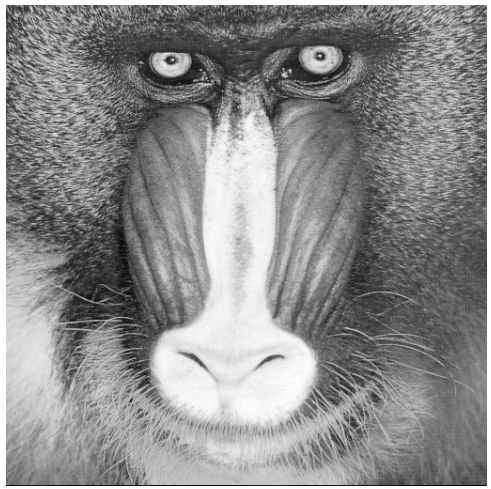


Additive color mixing

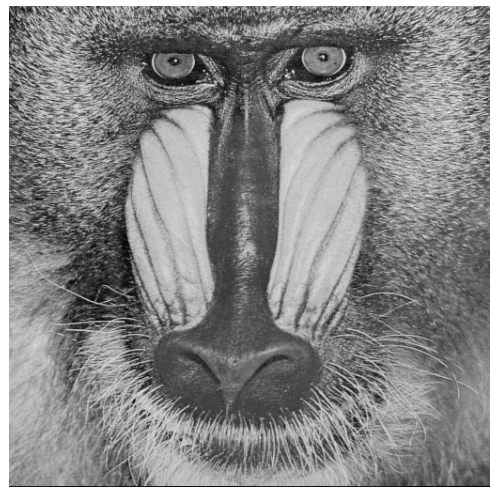
Subtractive color mixing

RGB Color

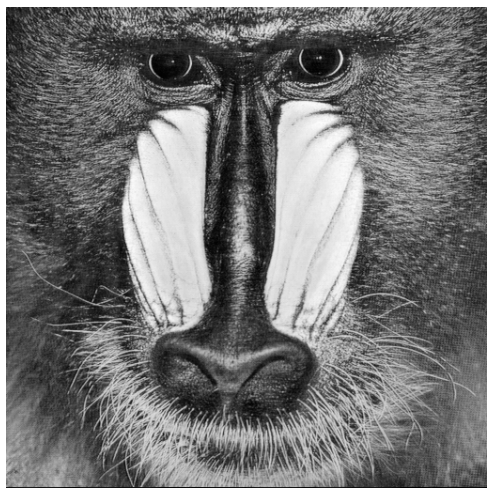
R



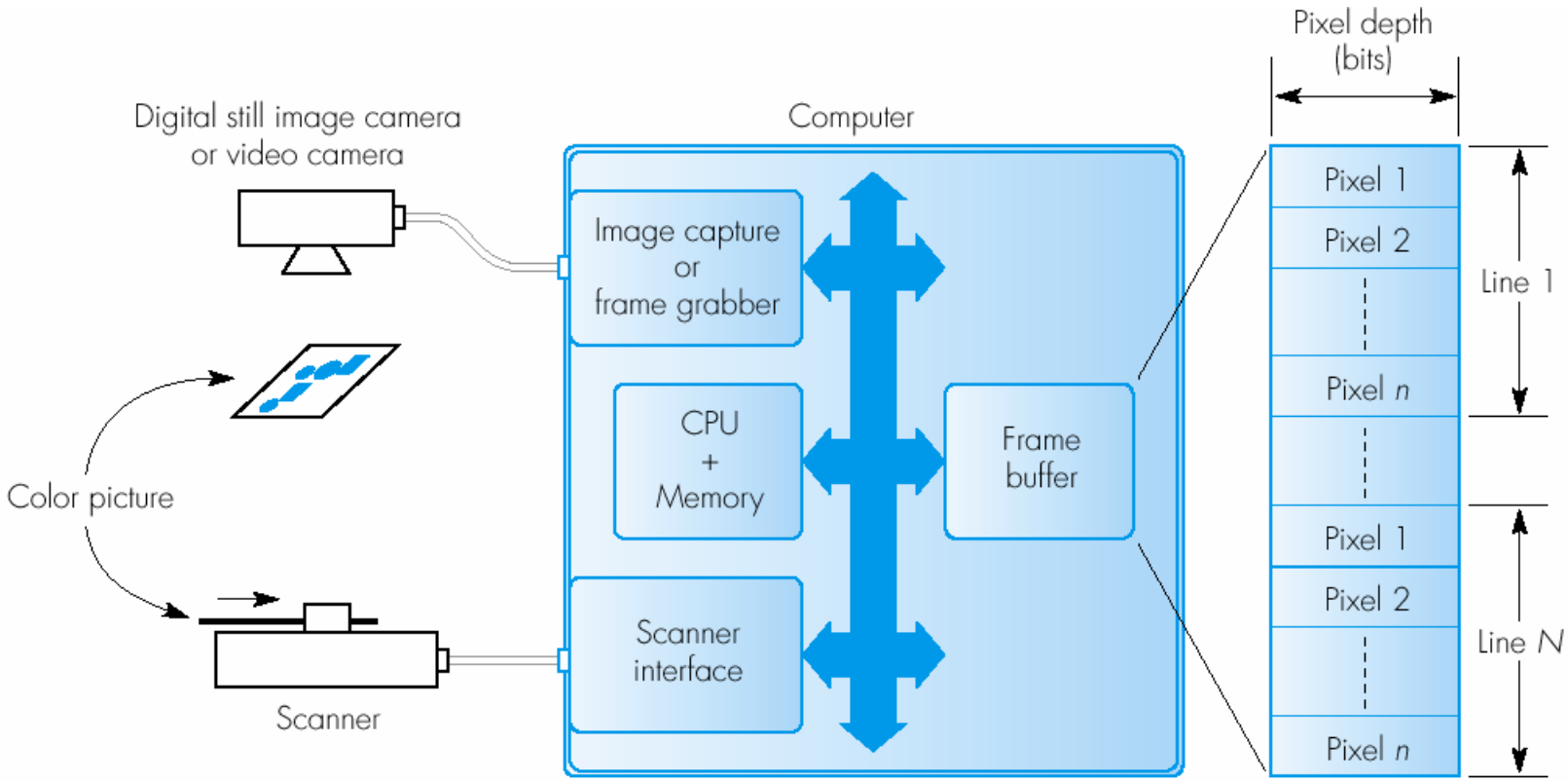
G



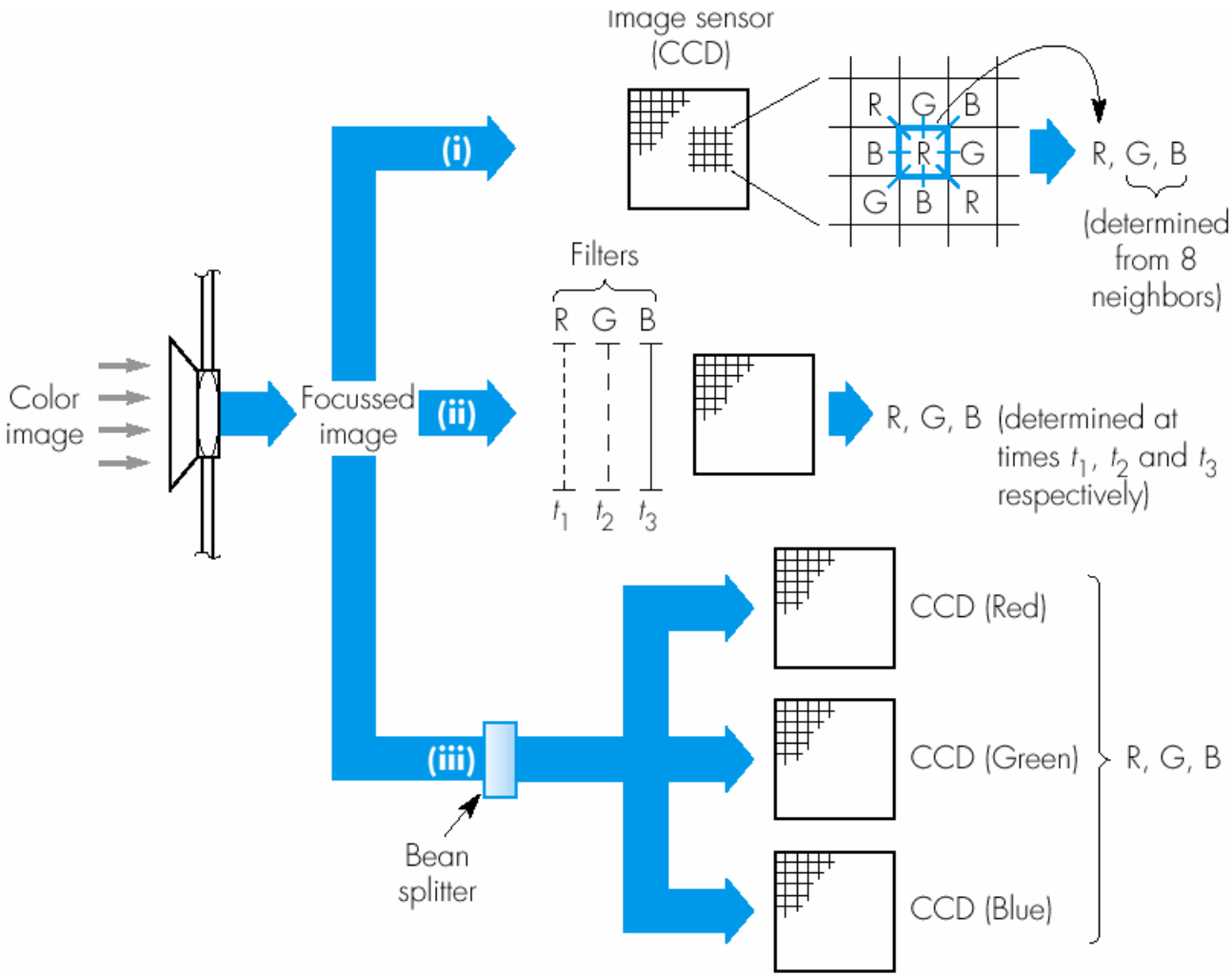
B



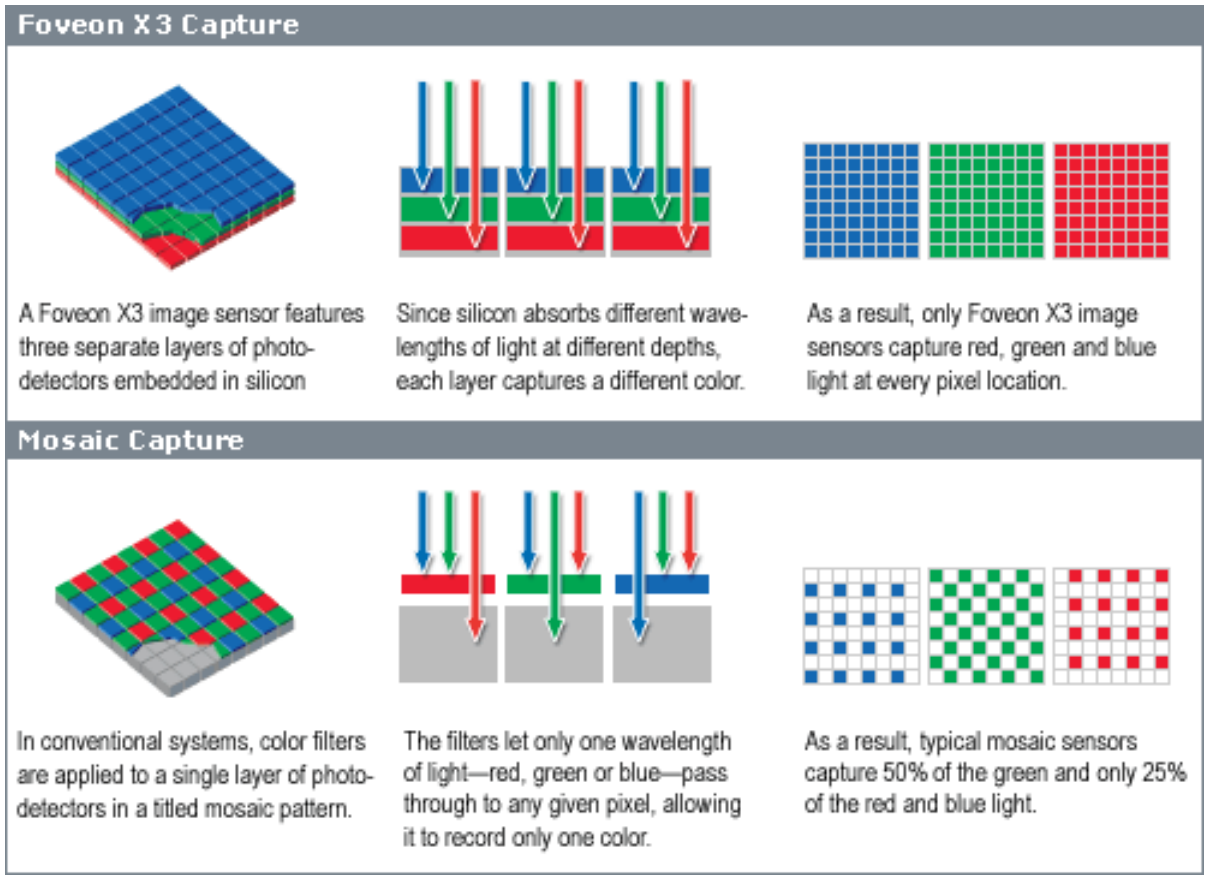
Color Image Capture



RGB Signal Generation Alternatives

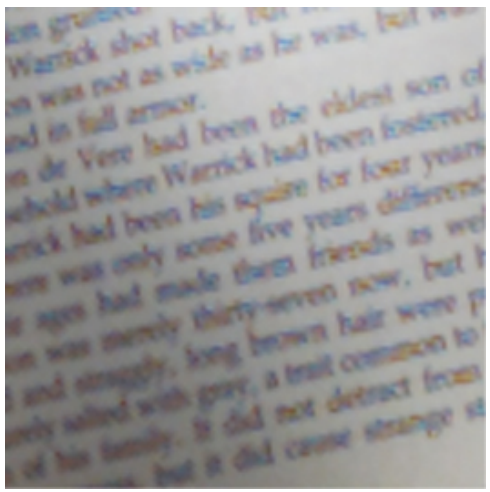


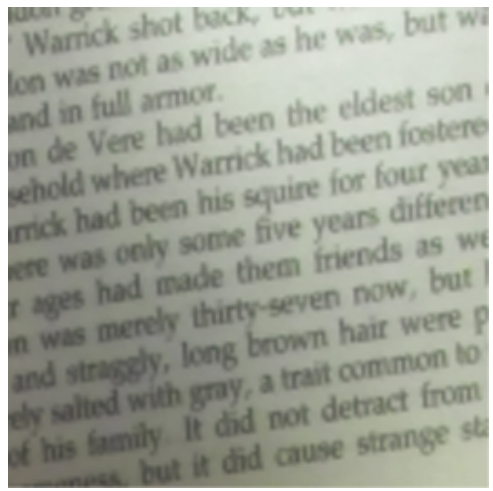
New Sensor Technology



http://www.foveon.com/

Comparison





McGurk Effect



Objectives

- Describe some of the activities in MMSP
- Just touch the “tip of the iceberg”
- Drive the point of the breadth and the interdisciplinary nature of the topic

What Follows

- Image and Video Recovery
  - Restoration
  - Super-resolution
- AV Signal Processing
- Segmentation
- Indexing and Summarization
- Tracking
- Wireless Video Transmission