



# Multimedia Systems

WS 2009/2010

Perception

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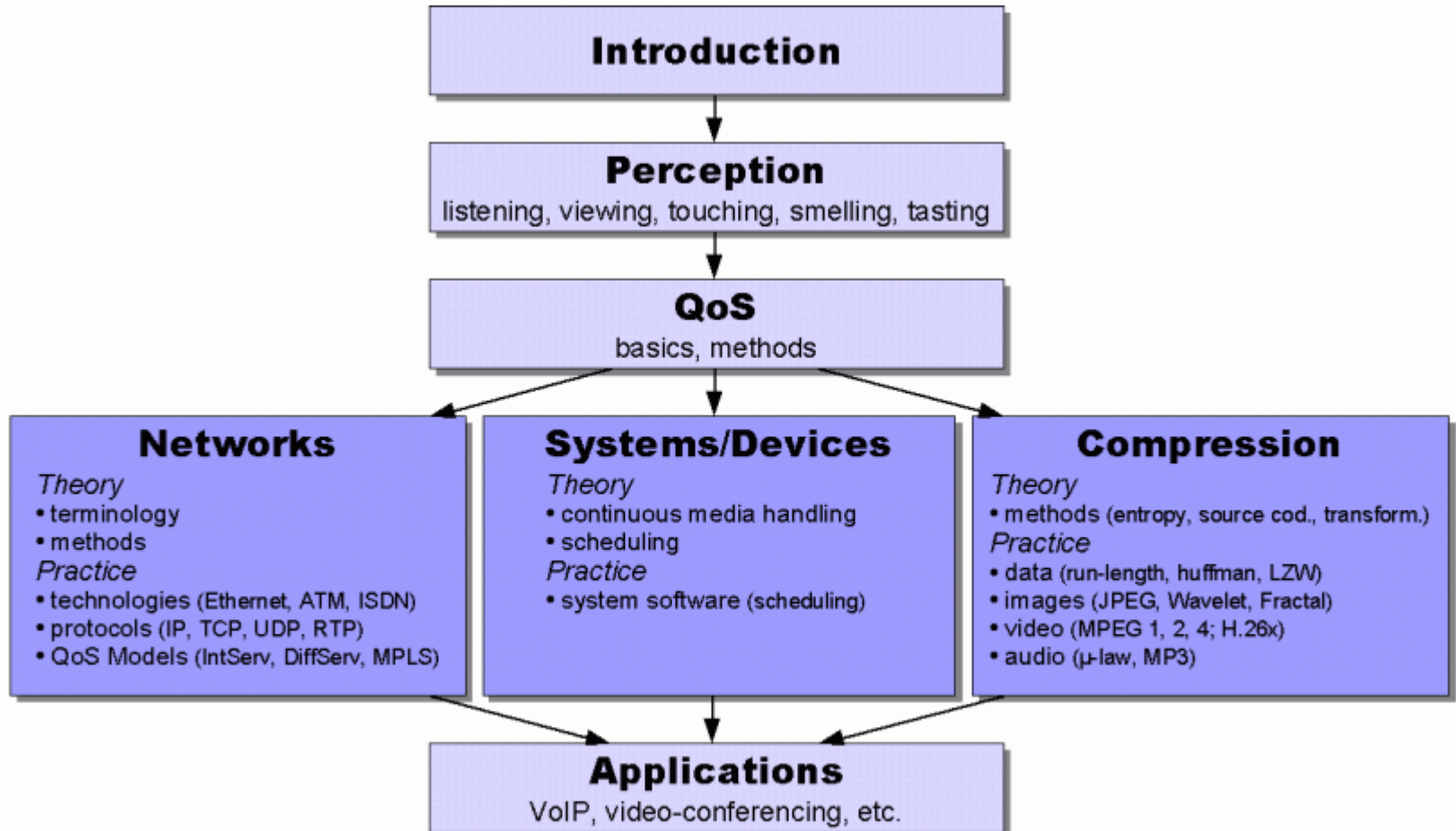
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# Outline

- Multimedia and Sense
- Enabling Multimedia
- Sense of Vision
- Sense of Hearing
- Other Senses

# Sitemap





# Videos about our senses

Videos taken from TV: "nano", 3sat (German):

- [Sehen](#)
- [Hören](#)
- [Riechen](#)
- [Tasten](#)
- [Schmecken](#)

# ▶▶▶ Senses and their Artificial Replacements



Vision

Audition

Olfaction

Gustation

Tactition



# Multimedia and Sense

Sense of		Mode of Sense	Display
vision hear smell taste balance	"5-sense"	visual auditory olfactory gustatory vestibular	optical acoustic - - -
pressure vibration cold warmth pain	skin touch	tactile	haptic
position power	<u><a href="#">proprioception</a></u>	kinesthetic	

# Perception without Multimedia Systems



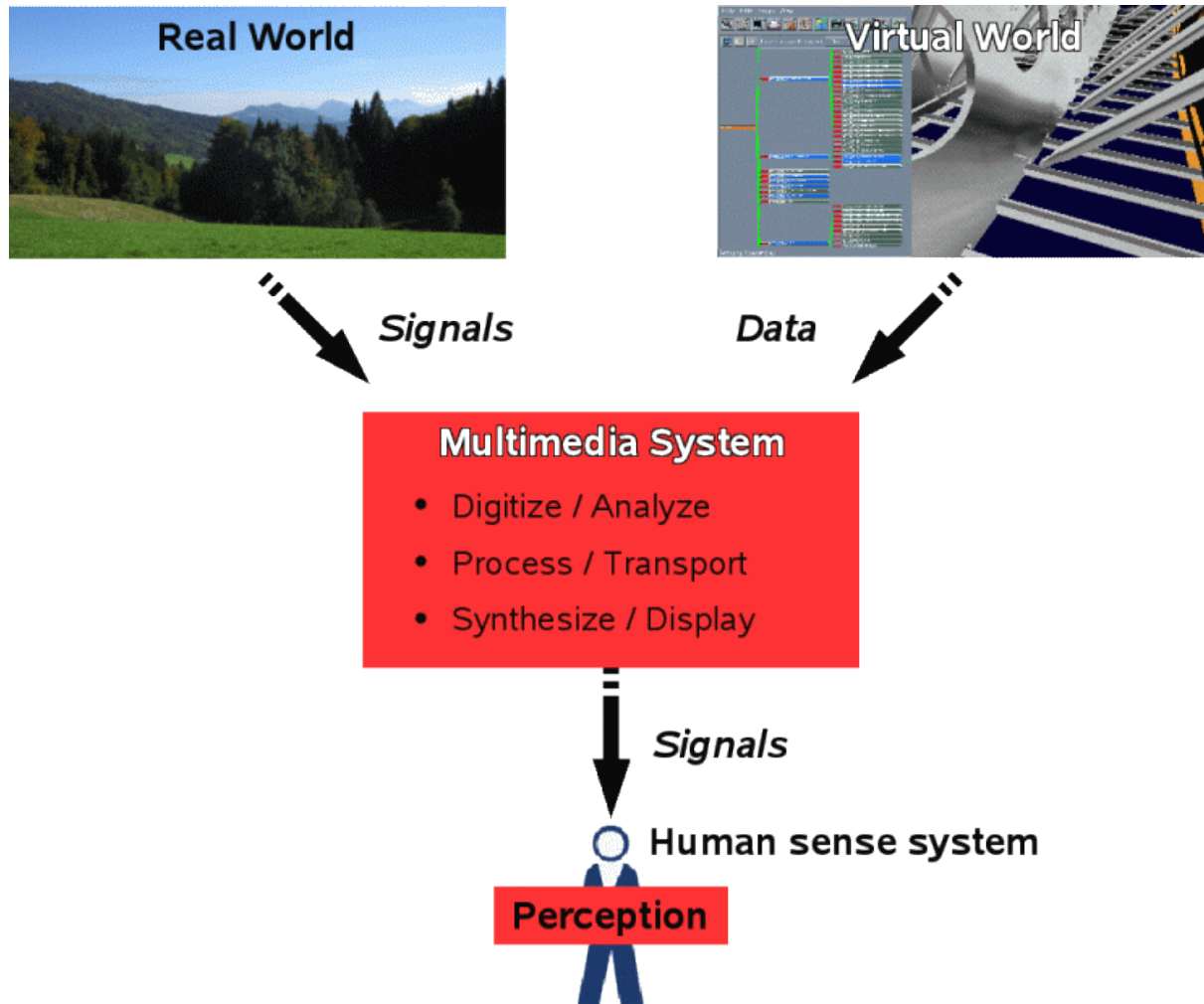
*Signals*



Human sense system

**Perception**

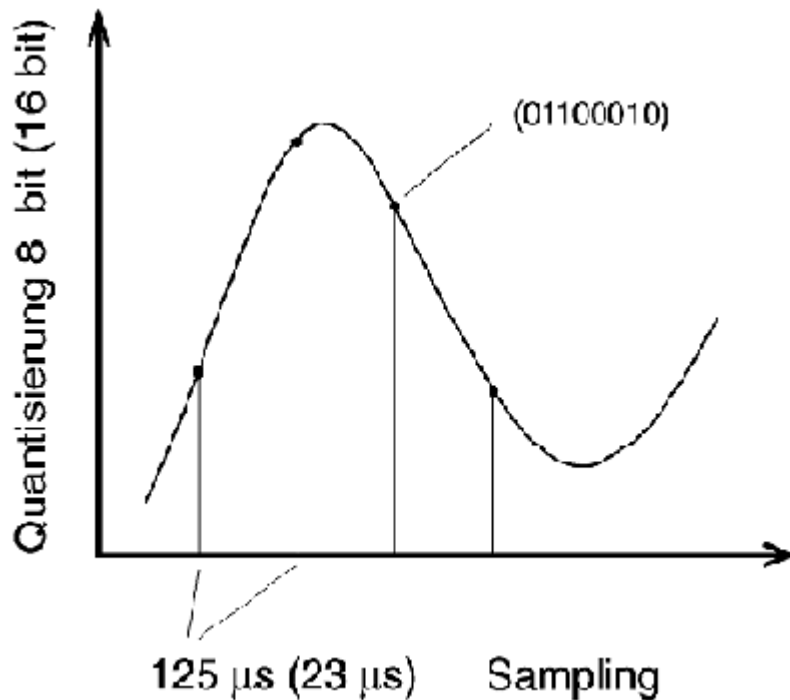
# Perception with Multimedia Systems





# Perception with Multimedia Systems

- The precondition to realize multimedia systems is digitalization of the environmental signals:



## Example:

The voice signal in the telephone system is limited to 4000 Hertz. With a sampling rate of 8000Hz (i.e. one sample each 125μs) and a quantization of 8 bit we get 64 kbit/s.

## Nyquist-Shannon-Theorem

# Enabling Multimedia

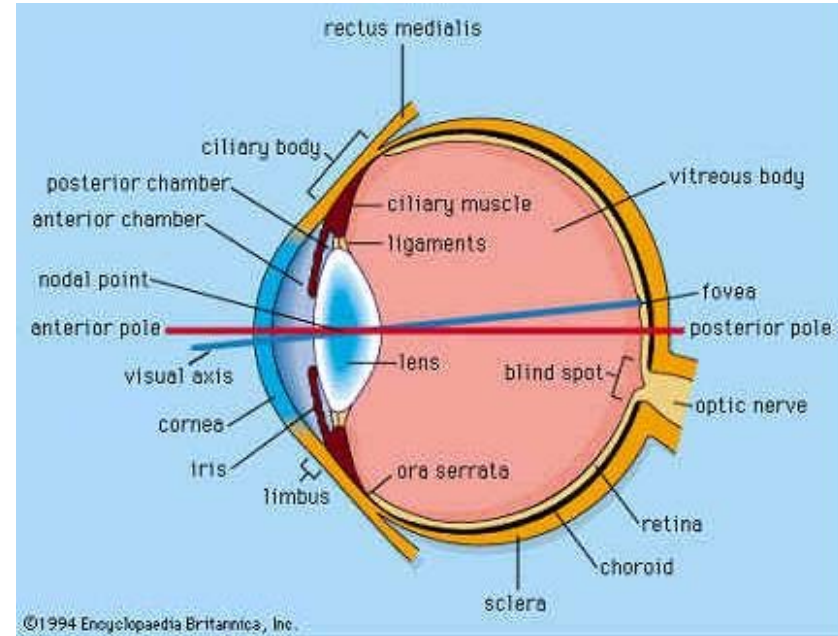
- Not all signals of the real environment have to be reproduced.
  - only those signals which cause the same perception in the sense organs as the original signals must be reproduced.
- Limited resolution of the human sensory system
  - artificial signals only have to be transmitted in a proper resolution.
- Limitation of intensity
  - Stimuli exceeding a certain limit of intensity cause damage
- The system of senses is widely modular.
  - For example, text only needs pictures; a speaker needs voice and picture

# Limitations of Sense Organs

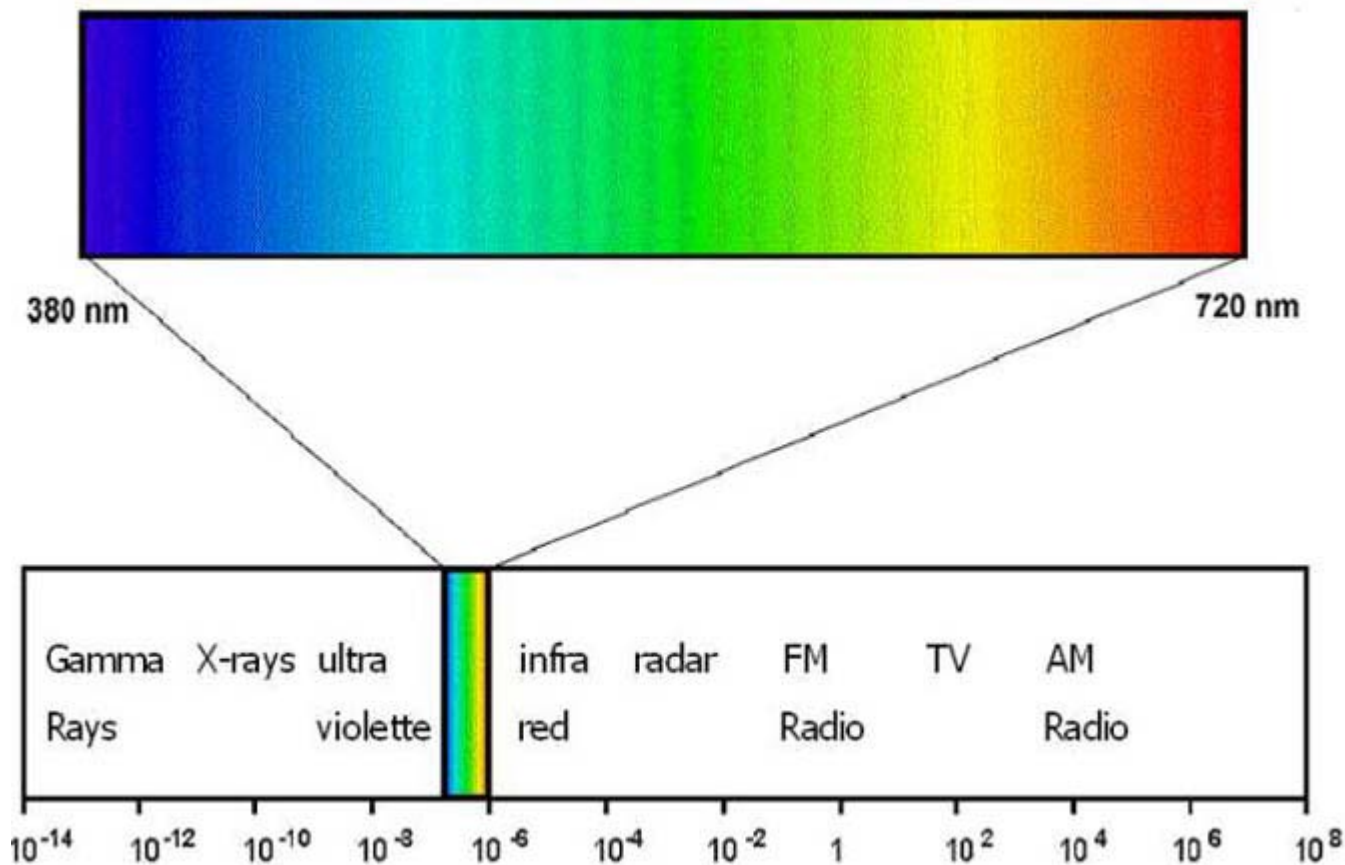
- All human sensory systems have a limited spectrum of perception. Signals beyond this spectrum cannot be perceived or lead to damage of the sense organ.
- **Examples:**
  - Audio: sound between 20 and 20000 Hertz
  - Visual: electromagnetic waves between 380 and 720 nm
  - Vibration: oscillations between 10 and 500 Hertz

# Sense of Vision

- The interior of the eyeball is covered with photosensitive cells known as the retina. The cells, known as **rods** and **cones**, form the layer of cells at the back of the retina. The backward-design of the retina results in the so-called blindspot.
- Rods** (110-125 million) are sensitive to very low levels of illumination and are responsible for our ability to see in dim light (scotopic vision). They contain a pigment with a maximum sensitivity at about 510nm, in the green part of the spectrum. **Scotopic** vision is completely lacking in color.
- Color vision is provided by the **cones** (photopic vision) (5-7 million), of which there are three distinct classes with absorptions at about 430nm, 530nm, and 560nm.



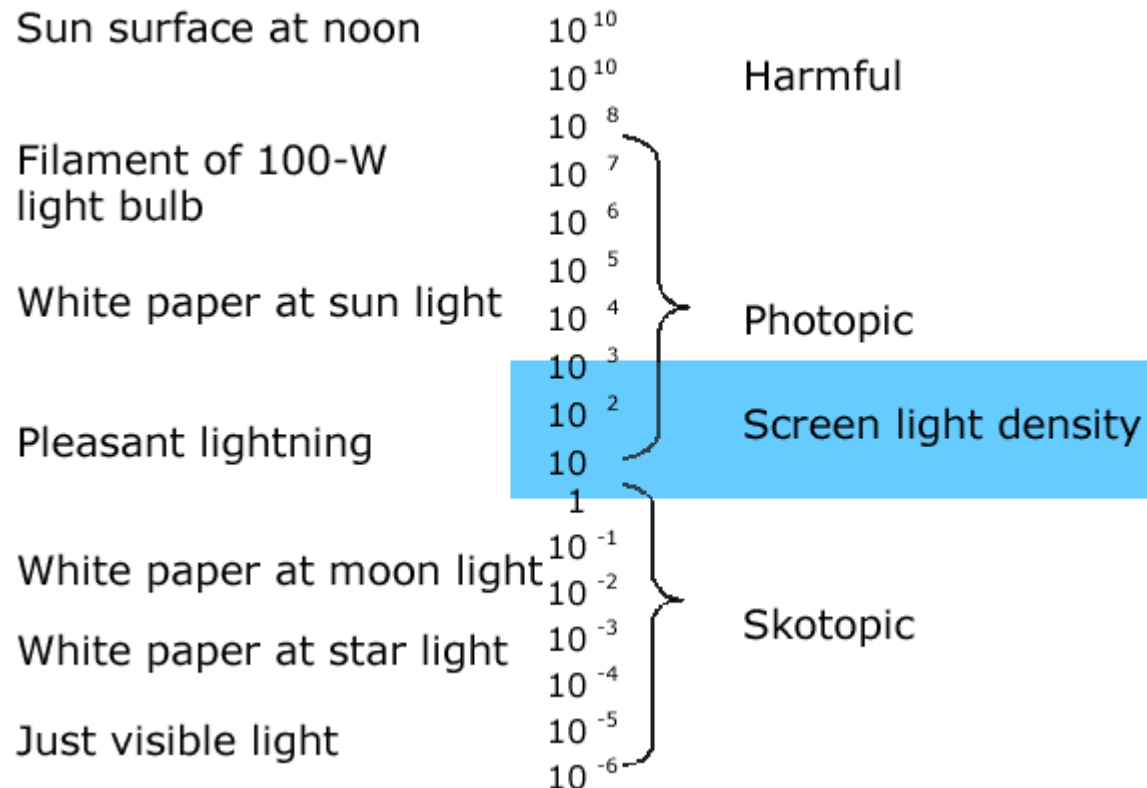
# Range of Visibility



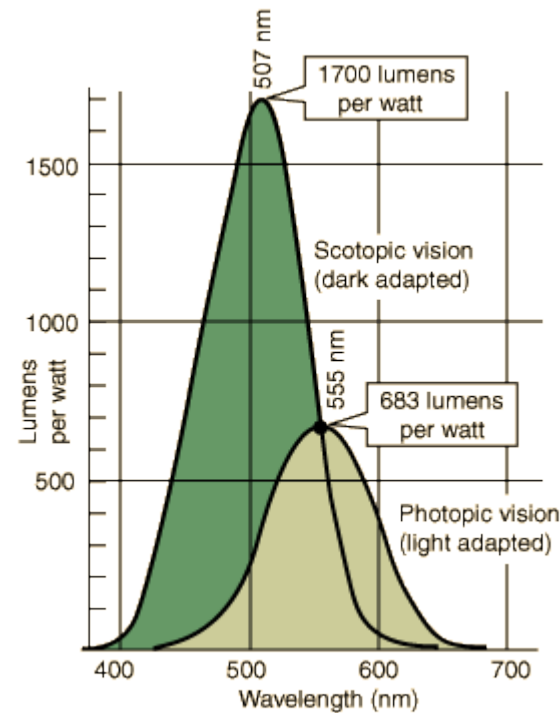


# Dynamic of See Sense

- **Candela per square meter**



# Spectral Sensitivity of Brightness

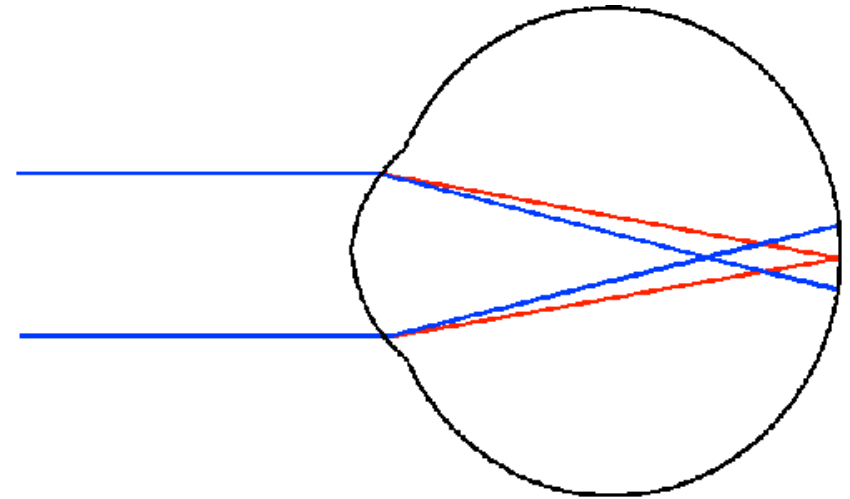


## Source and further Information

[WebVision](#) - summarizes the recent advances in knowledge and understanding of the mammalian retina

# Chromatic Aberration (1)

Because the maximum of energy of the red and blue phosphor of a screen are relatively apart from each other we have an optical depiction error by blue-red contours. This error is called **chromatic aberration**. Rays with different wavelengths will be focused at different positions at the retina. One can observe a blue light up of the contour.







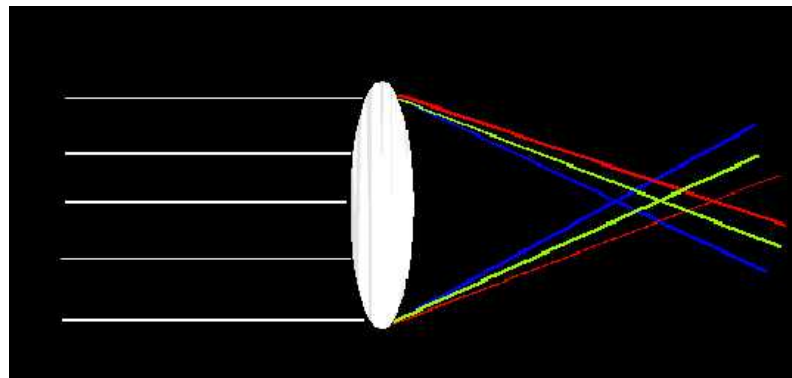
## Chromatic Aberration (2)

*Chromatic  
Aberration*

# Chromatic Aberration (3)

refraction power of the eye

	<i>wavelength (nm)</i>	<i>color description</i>	<i>refraction difference</i>	
	687	dark red	+0.34 <--	
	656	medium red	+0.25	cannot be
reference point -->	589	yellow	0	focused
	527	yellow-green	-0.30	simultaneously
	486	blue	-0.58	
	431	blue-violet	-1.07 <--	



# ▶▶▶ Red/Green-System: Search for Food (1)

- Find the fruit faster than your competitor



View of a blue/yellow-being.

## ▶▶▶ Red/Green-System: Search for Food (2)

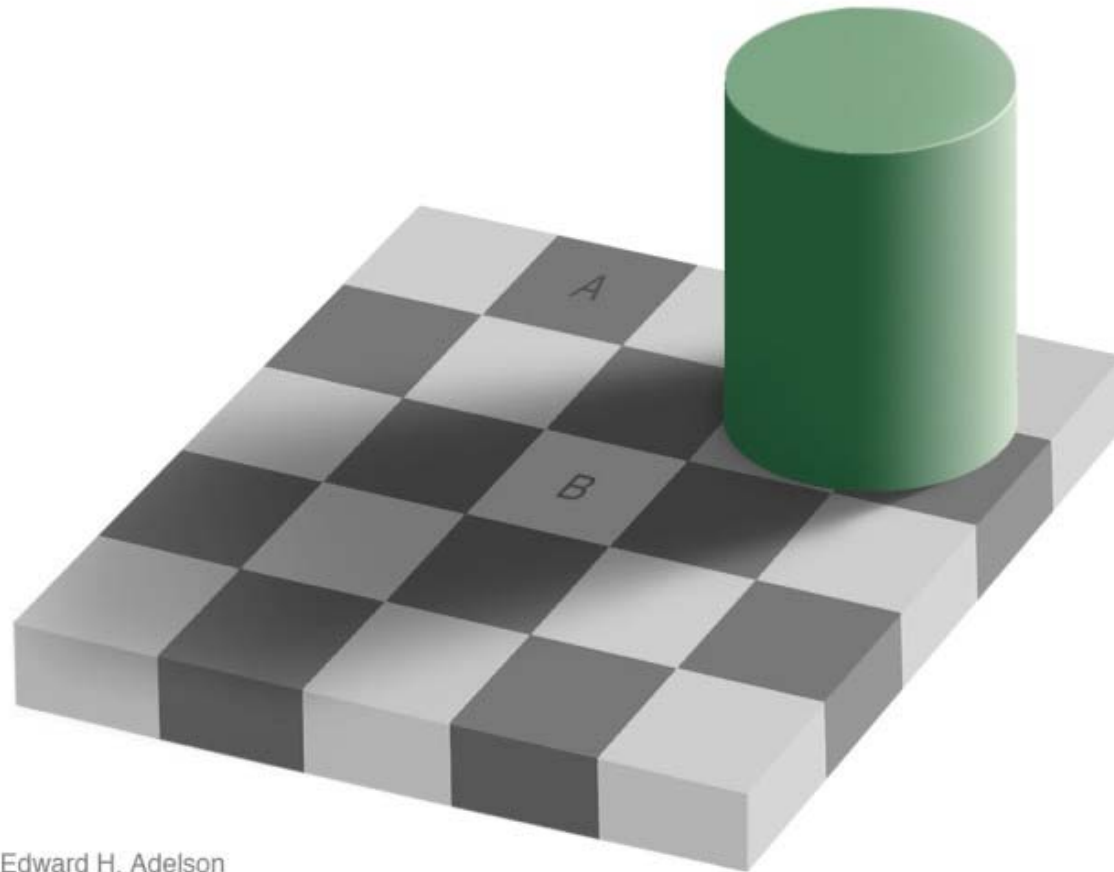
- Find the fruit faster than your competitor



View of a blue/yellow/red/green-being.



# Invariant of Lighting (1)

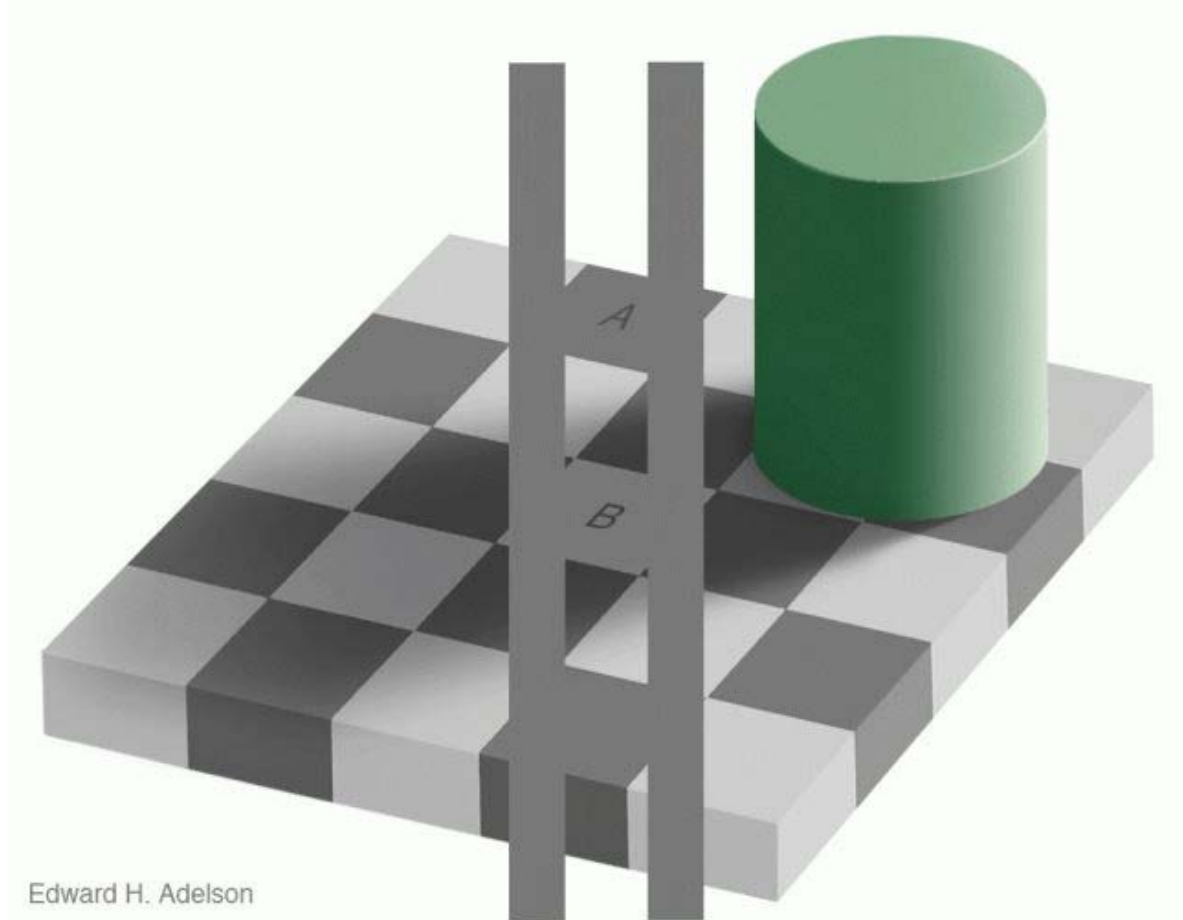


Edward H. Adelson

The light check in the shadow is the same gray as the dark checks outside the shadow.



## Invariant of Lighting (2)



Edward H. Adelson



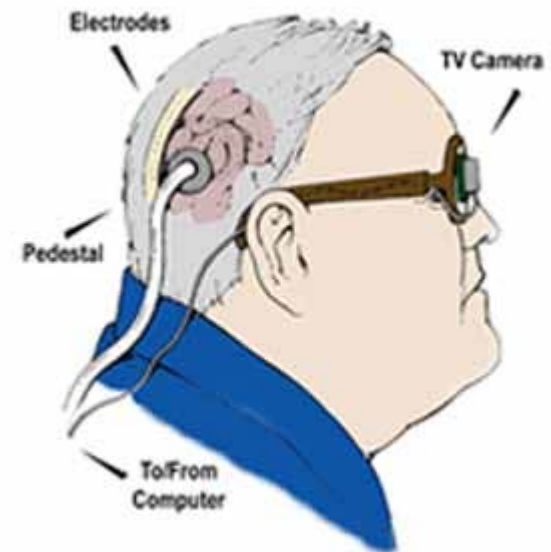
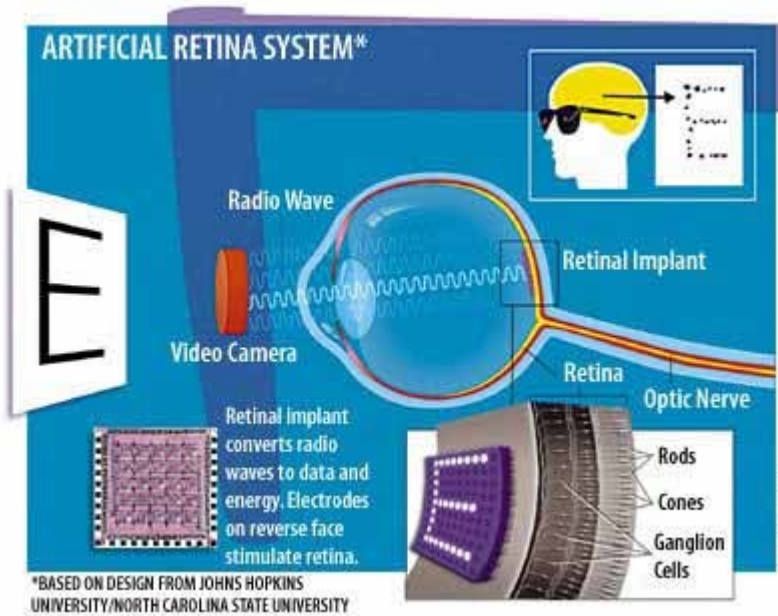
# Knowledge versus Shadow



[Videoclip](#)

Source: Max Planck Institute for Biological Cybernetics

# Artificial Retina

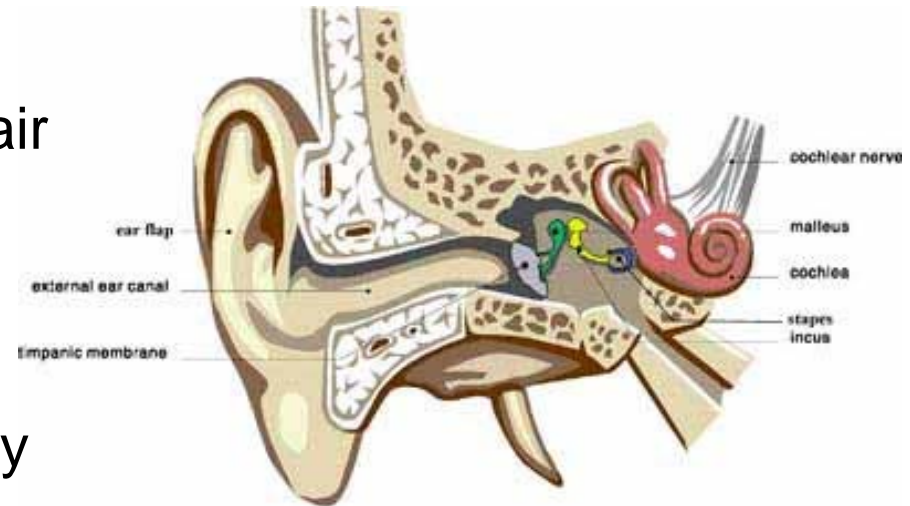


<http://www.seeingwithsound.com/etumble.htm>



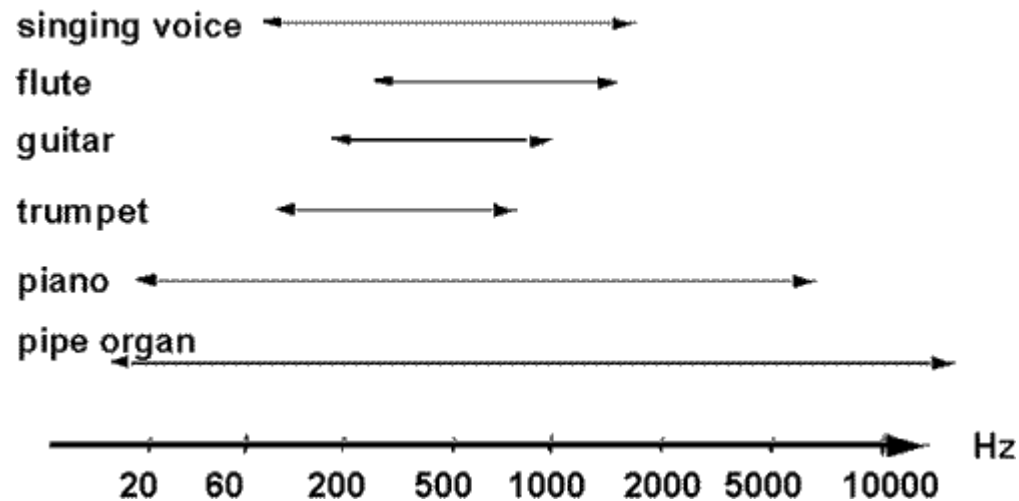
# Sense of Hearing

- 16.000 receptors (hair cells) in a human cochlea
  - 3500 inner cells
  - 12000 – 20000 outer hair cells
- Hearing range 20 Hz to 20000 Hz
- Number of fibers in auditory nerve 28000
- Detection threshold 10–12  $\text{W/m}^2$ 
  - Dynamic range 120 dB (12 orders of magnitude)

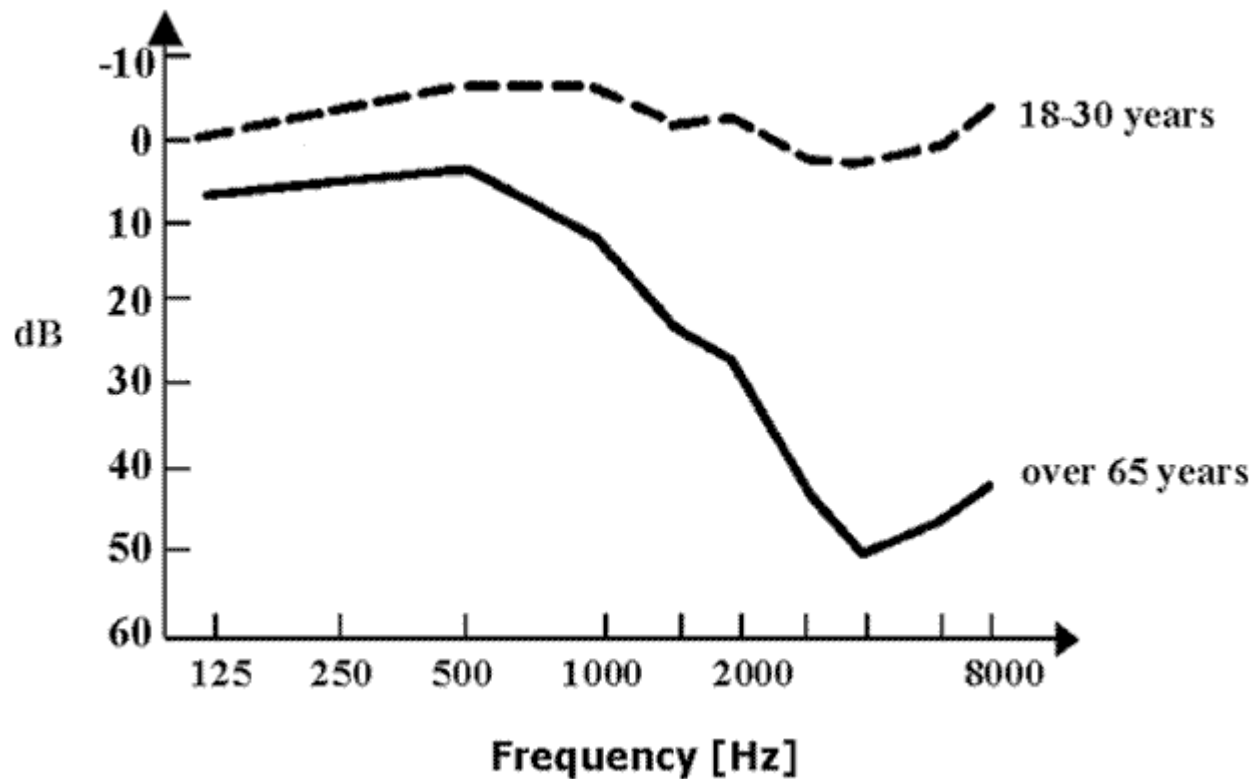


# Human Aural Properties

- **Human ear can detect sounds between ~20Hz and 20kHz:**
  - Total audio range: 5Hz - 50kHz



# Hearing Range



# Decibel

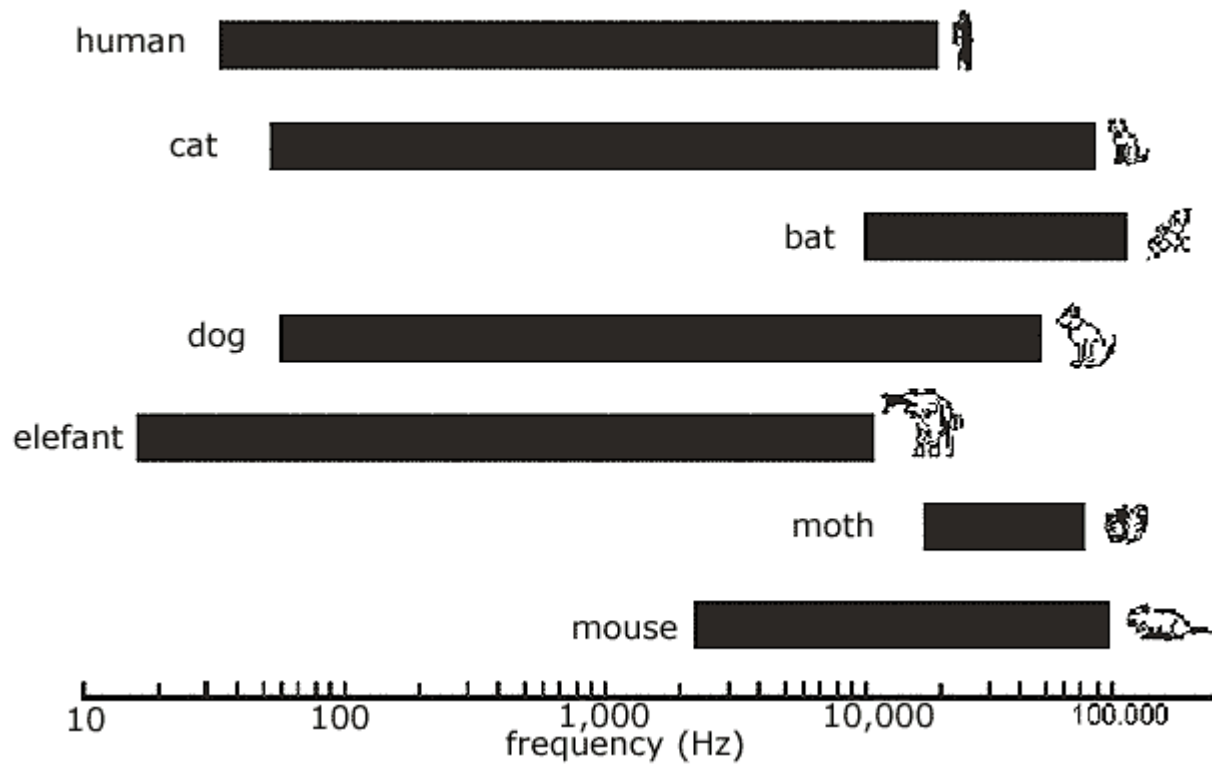
- The decibel (dB) is a common unit of measurement for the relative loudness of a sound or, in electronics, for the relative difference between two power levels.

$$dB = 10 \log_{10} \left( \frac{I}{I_0} \right)$$

- In sound, decibels measure a scale from the threshold of human hearing, 0 dB, upward towards the threshold of pain, about 120-140 dB.

$$I := 2 * I_0 \rightarrow 3dB$$

# Audio-Frequency Limitations



# Dynamic of Hearing

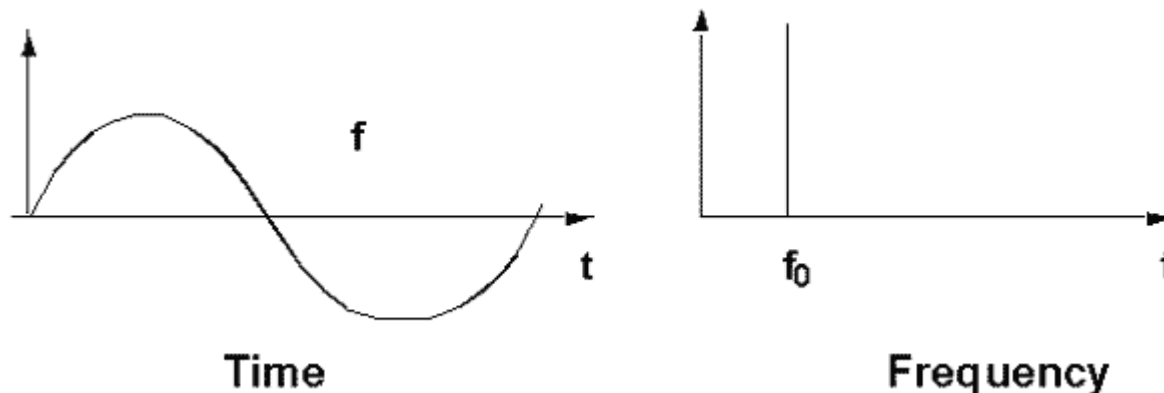
rocket launching	180	
wind channel	160	
	150	
jet take off	<b>140</b>	<b>threshold of pain</b>
rifle fire	130	
propeller-aircraft take off	120	
	<b>110</b>	<b>permanent damages</b>
subway	100	
Niagara falls	<b>90</b>	<b>damages</b>
old vacuum cleaner	80	
traffic noise	70	
chat between two persons	60	
quiet restaurant	50	
residential district by night	40	
empty cinema	30	
sound of leaves in the wind	20	
breath	10	
threshold of hearing	0	

- max. signal-to-noise ratio of a CD-player: 96dB

Values in dB

# The Physics of Acoustics

- **Sound can be considered in one of two ways:**
  - In the time domain
  - In the frequency domain
  - Transformation is accomplished by a Fourier transform
- **Fourier:**
  - Any waveform can be created by a series of sine waves summed together



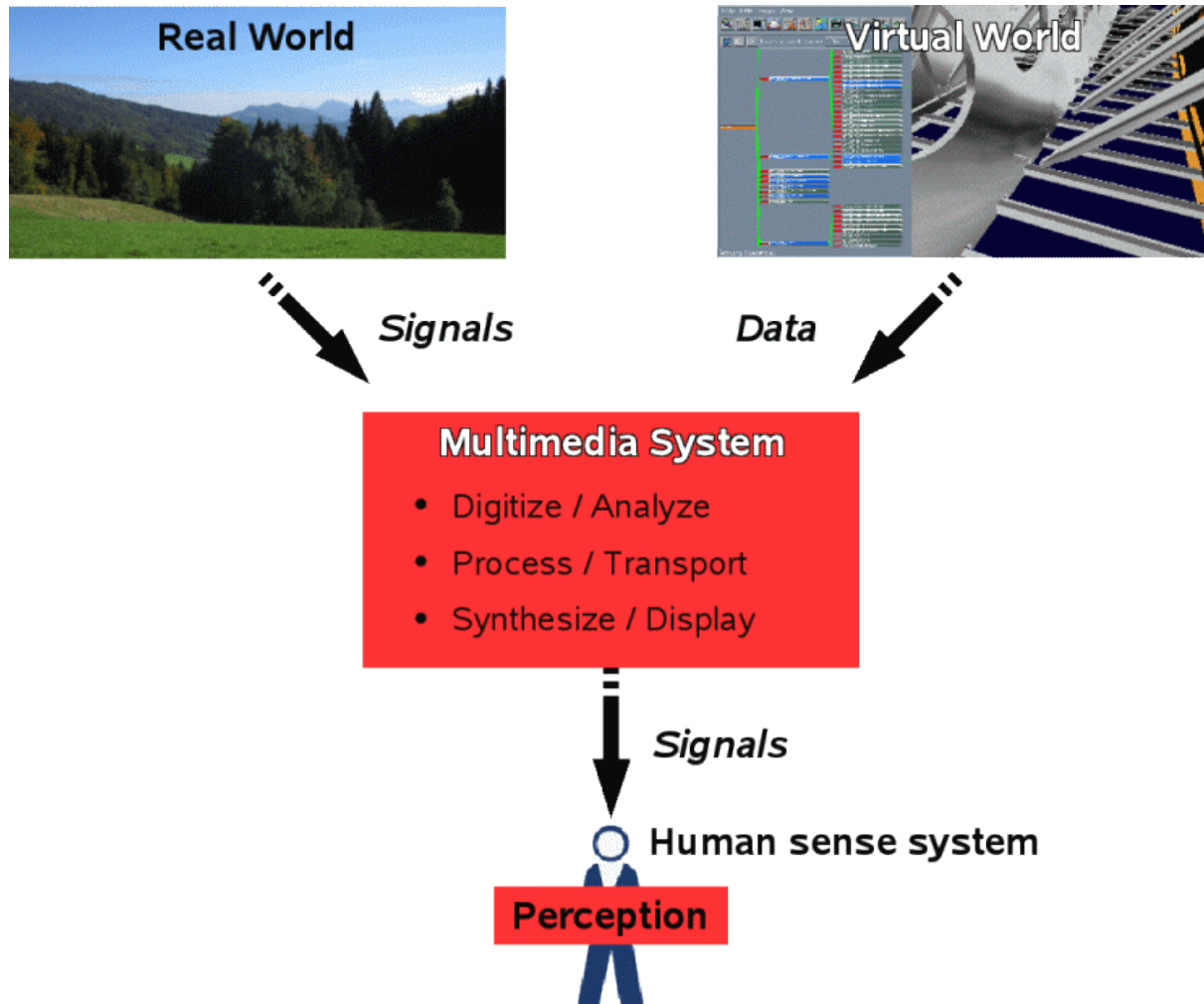


# Other Senses

- Consideration of other senses is beyond the scope of this lecture
  - Sense of smell  
(e.g. "telesmell", see [article in "Spiegel" about smell in movie theaters](#))
  - Sense of taste
  - Sense of touch/vibration (e.g. force-feedback input devices)
  - Sense of balance



# Perception with Multimedia Systems





## Interesting Links (1)

- MIT encyclopedia of cognitive science  
<http://cognet.mit.edu/>
- Mark Newbold's Animated Necker Cube  
<http://dogfeathers.com/java/necker.html>
- Perception  
<http://psych.la.psu.edu/clip/Perception.htm>
- Artificial Retina Development  
[http://www.nsf.gov/news/frontiers\\_archive/7-97/7retina.jsp](http://www.nsf.gov/news/frontiers_archive/7-97/7retina.jsp)



## Interesting Links (2)

- The Human Body's Senses: Hearing Theme Page  
<http://www.cln.org/themes/hearing.html>
- The Human Body's Senses: Sight Theme Page  
<http://www.cln.org/themes/sight.html>
- The Human Body's Senses: Smell Theme Page  
<http://www.cln.org/themes/smell.html>
- The Human Body's Senses: Taste Theme Page  
<http://www.cln.org/themes/taste.html>
- The Human Body's Senses: Touch Theme Page  
<http://www.cln.org/themes/touch.html>



## Interesting Links (3)

- That's Tasty  
<http://faculty.washington.edu/chudler/tasty.html>
- Touching...  
<http://sln.fi.edu/qa97/me10/me10.html>



## Interesting Links (4)

- Retina reference  
<http://retina.anatomy.upenn.edu/~lance/retina/retina.html>
- Rotating mask and other visual illusions  
<http://www.kyb.tuebingen.mpg.de/bu/demo/index.html>
- Optical illusions  
<http://www.kyb.tuebingen.mpg.de/bu/demo/index.html>
- Optical illusions and visual phenomena  
<http://www.michaelbach.de/ot/index.html>