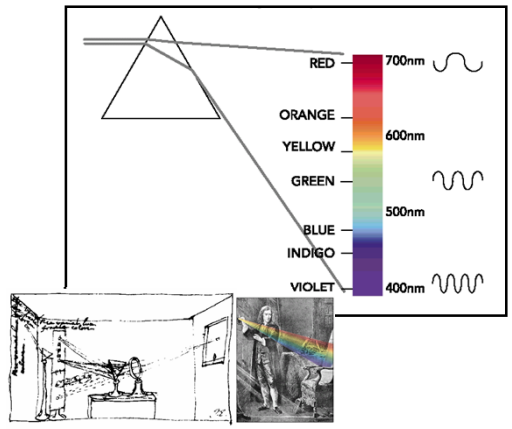
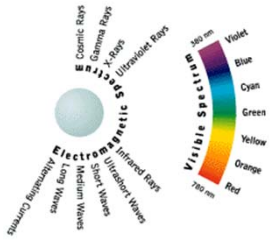
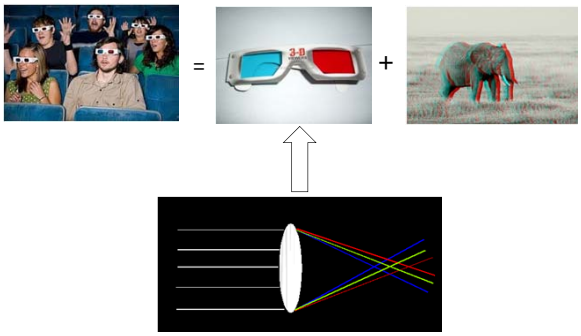
Modelli della visione e fotografia digitale

R. Schettini
D.I.S.Co. (Dip. Informatica, Sistemistica e Comunicazione)
Università degli Studi di Milano-Bicocca,
Viale Sarca 336, 20126 Milano Italy
ww.ivl.disco.unimib.it

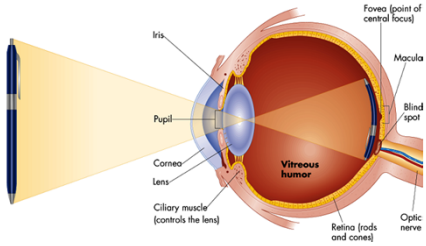




"Indeed, rays, properly expressed, are not coloured".
Isaac Newton, Opticks (1704)

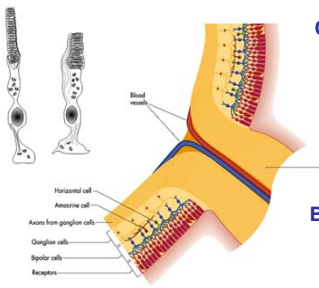


Fisiologia della Visione



Retina: membrana sensibile dell'occhio; se l'occhio fissa un oggetto, l'immagine si forma nella fovea.

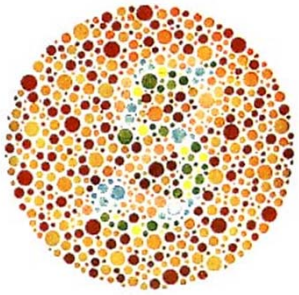
Fisiologia della Visione



Coni
- visione fotopica (diurna);
- colori.

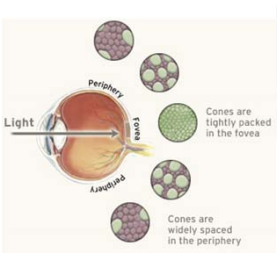
Bastoncelli
- visione scotopica (notturna);
- abbondanti nella periferia della retina.

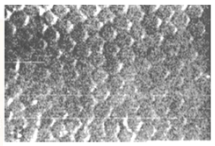
Test di visone (Ishihara)



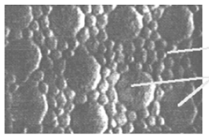
Visione normale: 5; Daltonismo per rosso/verde: 2

Fisiologia della Visione





Coni nella fovea



Coni e bastonelli In periferia

Digitalizzazione di immagini

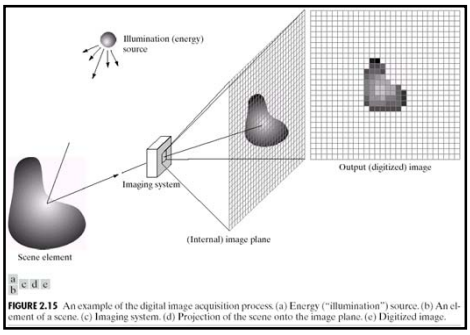


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

- una immagine e' un proiezione di una scena 3D sul piano immagine (2D).
- proiezione che viene poi digitalizzata.

Campionamento e quantizzazione

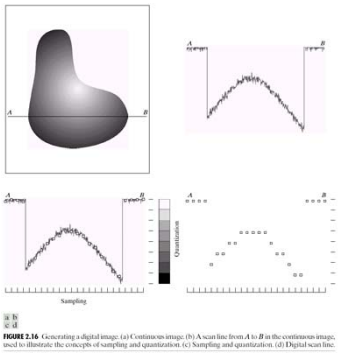
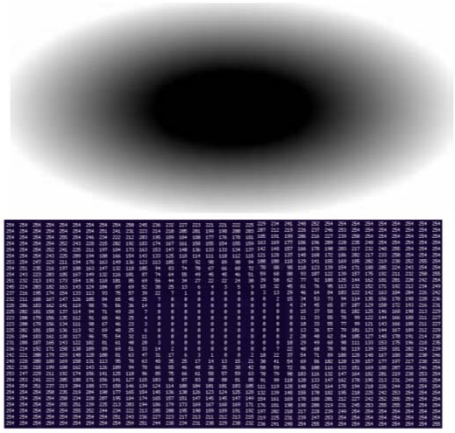
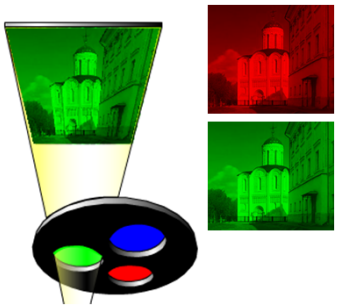


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from A to B in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

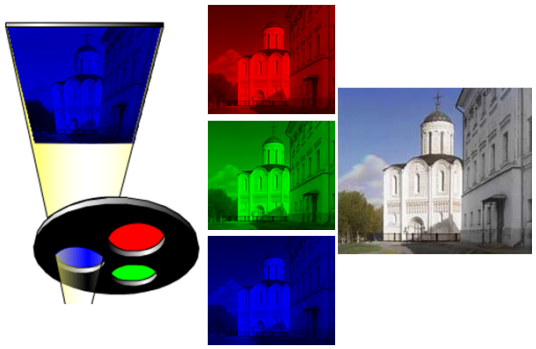


Field sequential

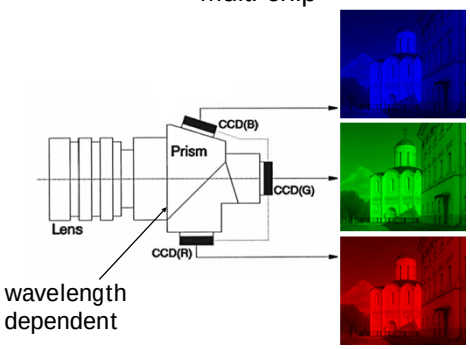
Field sequential



Field sequential



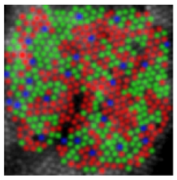
Multi-chip

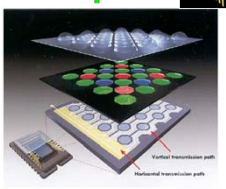


wavelength dependent

Fisiologia della Visione e camere digitali

Cone Receptor Mosaic
(Roorda and Williams, 1999)



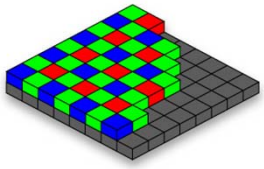


L-cones M-cones S-cones

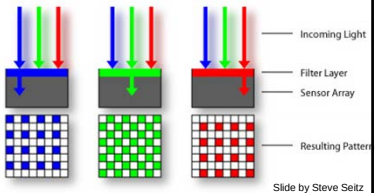
La proporzione fra coni “rossi”, “verdi” e “blu” e’ circa 64%:32%:2%

La risoluzione nominale si ottiene per interpolazione

Practical Color Sensing: Bayer Grid



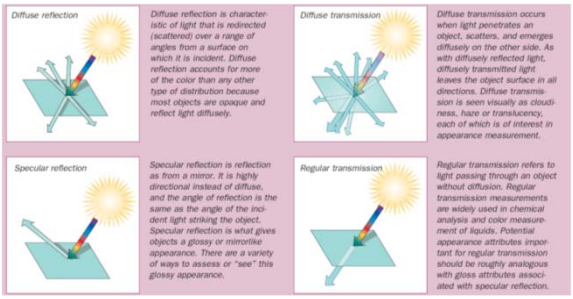
- Estimate RGB at ‘G’ cells from neighboring values



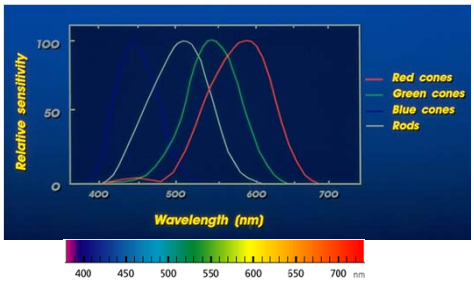
http://www.cooldictionary.com/words/Bayer-filter.wikipedia

Slide by Steve Seitz

Interaction of illuminant and surface



Sensibilita' relativa dei coni e dei bastoncelli



Interaction of illuminant and surface

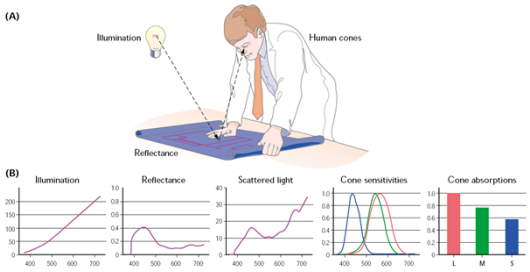
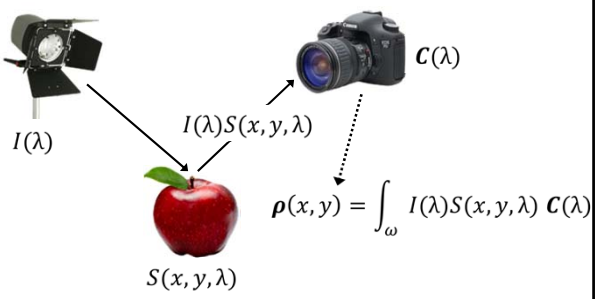
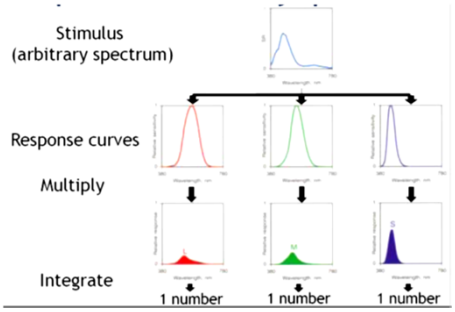


Figure 8.3 The physical factors governing sensor absorptions. The wavelength composition of the light sent to the eye (the color signal) depends on the ambient illumination and the surface reflectance. The number of photons absorbed in each of the eye's receptor types depends on the relative spectral absorption of the media of the eye and the photopigments within the receptors.

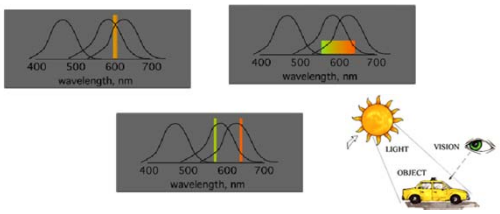
Image formation



Trichromacy

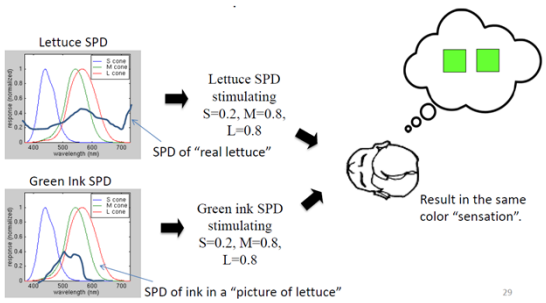


Imaging e metameria

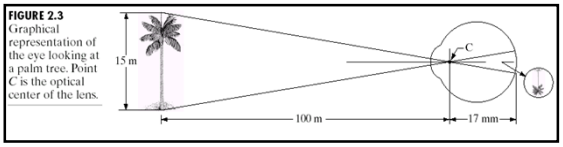


Queste tre distribuzioni spettrali di energia eccitano i coni in modo identico e sono quindi indistinguibili a livello sensoriale. Tali distribuzioni si dicono metameriche. I metameri possono avere distribuzioni anche molto diverse fra loro (vedi anche slide successiva).
Se cambia la sensibilità spettrale del dispositivo di imaging (e.g. occhio dell'osservatore, camera digitale, ...) le distribuzioni possono non essere piu' metameriche.

Imaging e metameria



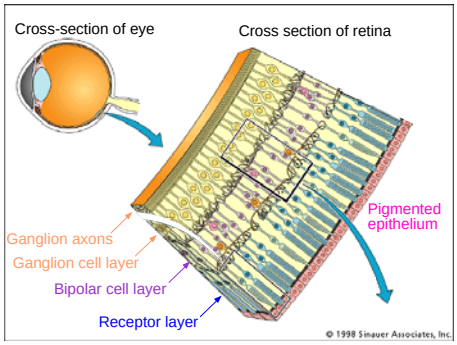
Formazione dell'immagine



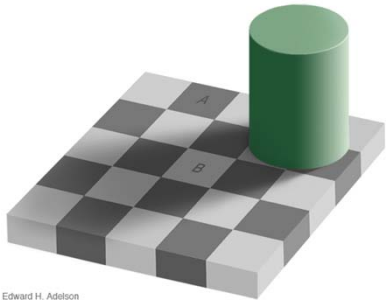
- La fovea puo' essere immaginata come un array di sensori
- La densità dei coni e' di circa 150,000 per mm^2
- *Possiamo immaginare la fovea come un array quadrato* 1.5 mm x1.5 mm avente *circa 337.000 fotosensori (580 x 580). …in pratica 0,33 Megapixel.*

Perche' si costruiscono camere con cosi' tanti pixel ?

La Retina

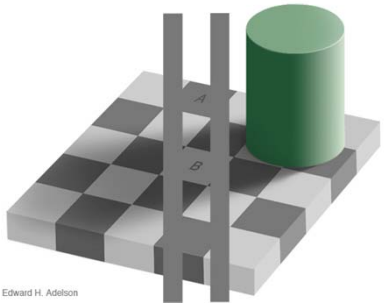


Color Imaging



Checker Shadow Illusion – [E. H. Adelson]

Color Imaging

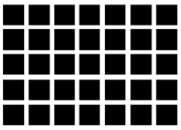


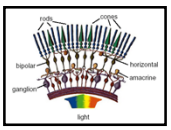
Checker Shadow Illusion – [E. H. Adelson]

Contrasto simultaneo

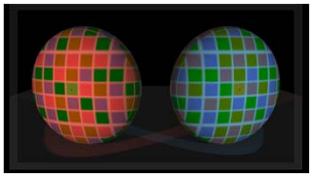
a b c

FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.



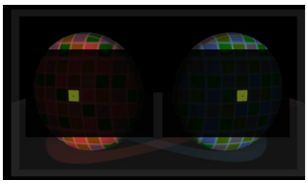


Color Imaging



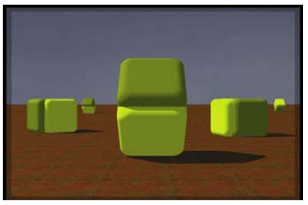
- Content © 2008 R.Beau Lotto
- http://www.lottolab.org/articles/illusionsoflight.asp

Color Imaging



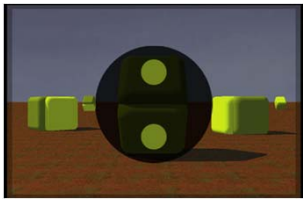
- Content © 2008 R.Beau Lotto
- http://www.lottolab.org/articles/illusionsoflight.asp

Color Imaging

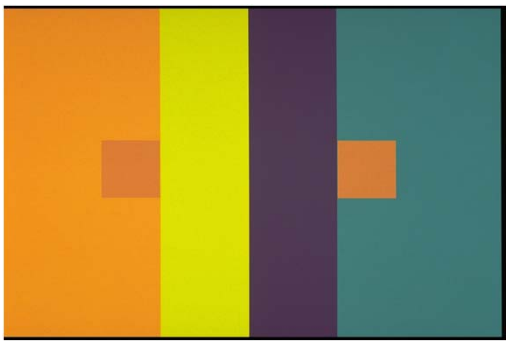


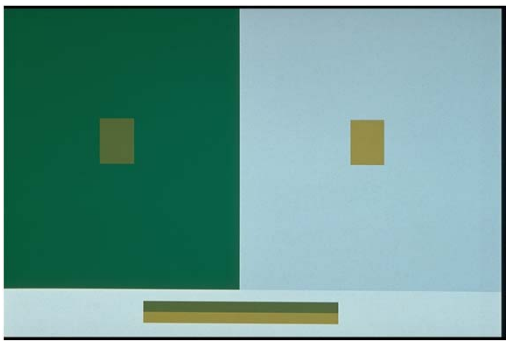
- Content © 2008 R.Beau Lotto
- http://www.lottolab.org/articles/illusionsoflight.asp

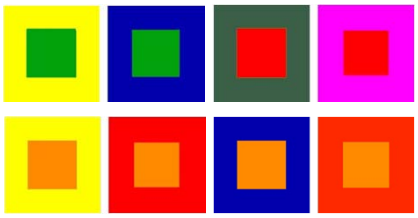
Color Imaging



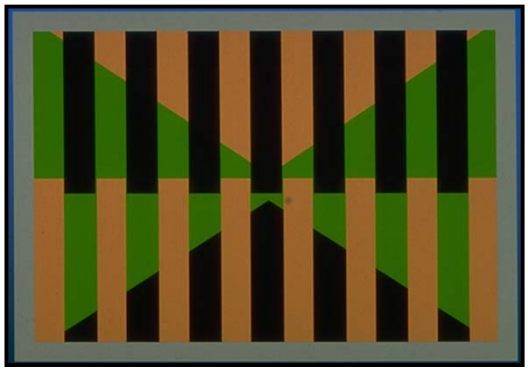
- Content © 2008 R.Beau Lotto
- http://www.lottolab.org/articles/illusionsoflight.asp



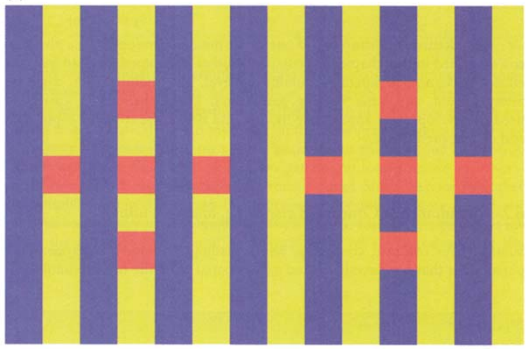




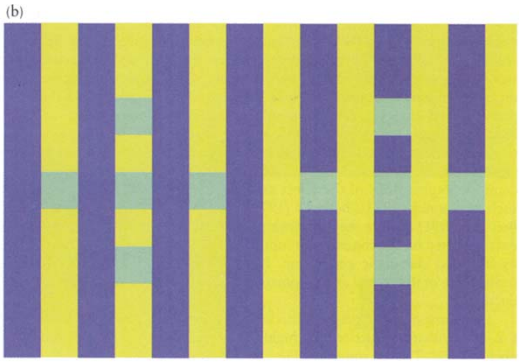
Background Change	Stimulus Color-Appearance Change
Darker	Lighter
Lighter	Darker
Red	Green
Green	Red
Yellow	Blue
Blue	Yellow



(a)

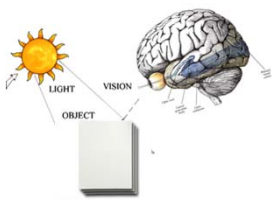


(b)



Adattamento e discriminazione

- Può un foglio di carta bianco apparirci nero (anche se non siamo al buio) ?



Legge di Weber

If you lift up and hold a weight of 2.0 kg, you will notice that it takes some effort. If you add to this weight another 0.05 kg and lift, you may not notice any difference between the apparent or subjective weight between the 2.0 kg and the 2.1 kg weights. If you keep adding weight, you may find that you will only notice the difference when the additional weight is equal to 0.2 kg. The increment threshold for detecting the difference from a 2.0 kg weight is 0.2 kg.
The just noticeable difference (jnd) is 0.2 kg.

Now start with a 5.0 kg weight. If you add weight to this, you will find that the just noticeable difference is 0.5 kg. It takes 0.5 kg added to the 5.0 kg weight for you to notice an apparent difference.

For the weight of magnitude, I, of 2.0 kg, the increment threshold for detecting a difference was a ΔI of 0.2 kg.

For the weight of magnitude, I = 5.0 kg, the increment threshold ΔI = 0.5 kg.

The ratio of $\Delta I/I$ for both instances (0.2/2.0 = 0.5/5.0 = 0.1) is the same. This is **Weber's Law**.

Legge di Stevens

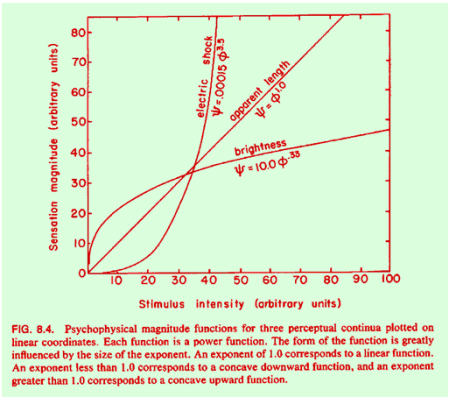
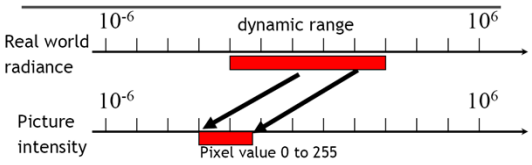
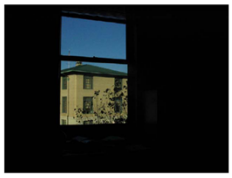


FIG. 8.4. Psychophysical magnitude functions for three perceptual continua plotted on linear coordinates. Each function is a power function. The form of the function is greatly influenced by the size of the exponent. An exponent of 1.0 corresponds to a linear function. An exponent less than 1.0 corresponds to a concave downward function, and an exponent greater than 1.0 corresponds to a concave upward function.

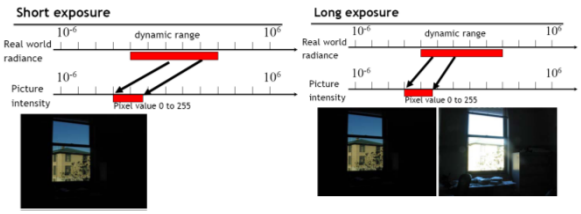
Range dinamico





Range dinamico: rapporto fra le intensita' massima e minima rivelabili. Il limite piu' alto viene indicato come "saturazione". Oltre tale limite i valori vengono "clippati". Il limite inferiore non corrisponde ad una assenza assoluta di segnale, in quanto vi e' il "rumore" del dispositivo.

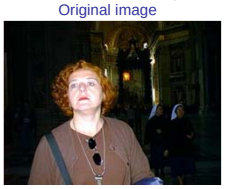
Range dinamico

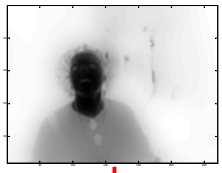


Modifiche del contrasto

under-exposed and over-exposed areas

Original image





Stretching and clipping
Saturation gain

Local contrast correction

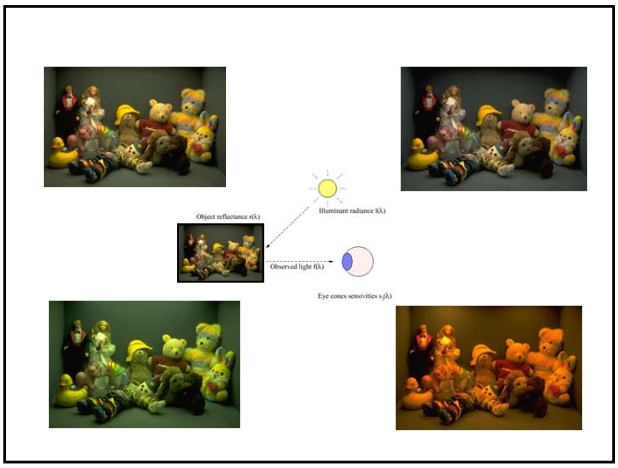


Image formation

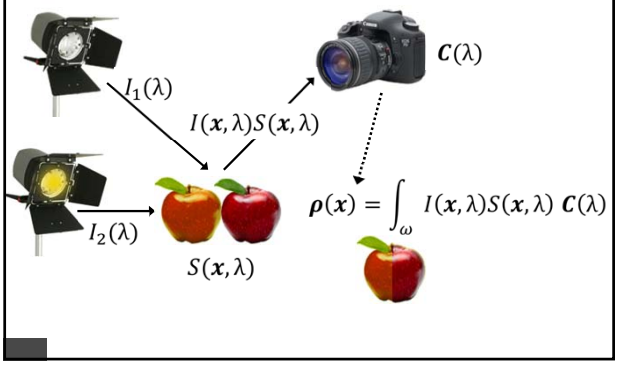
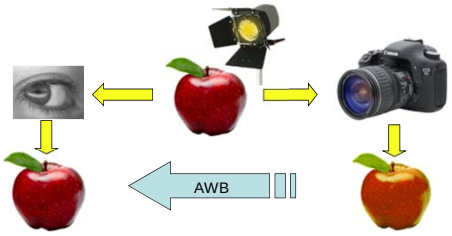
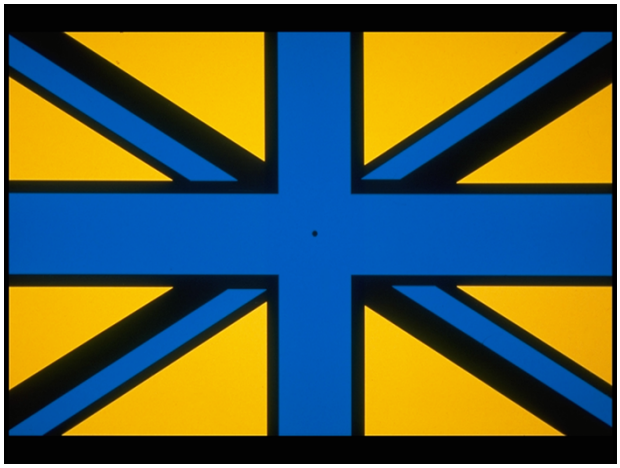
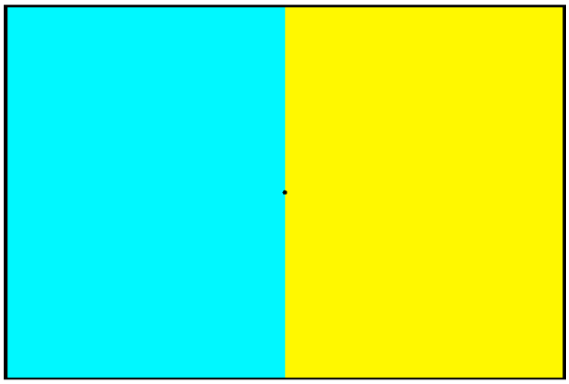
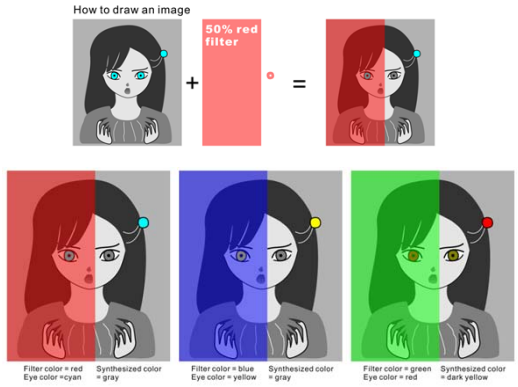


Image processing







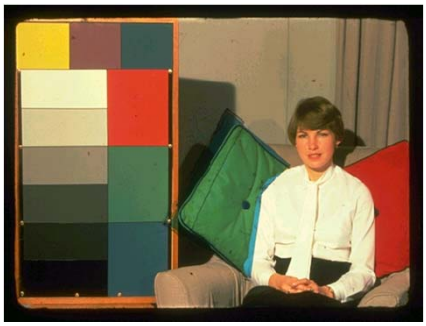


http://www.psy.ritsumei.ac.jp/~akitaoka/colorconstancye.html

Meccanismi per la costanza del colore

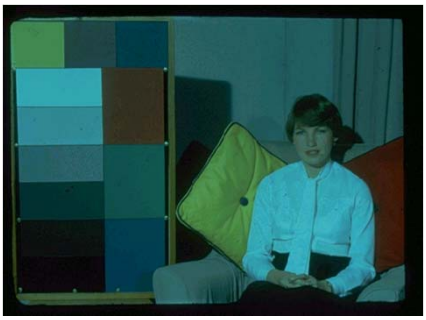
- Color imaging

Meccanismi per la costanza del colore



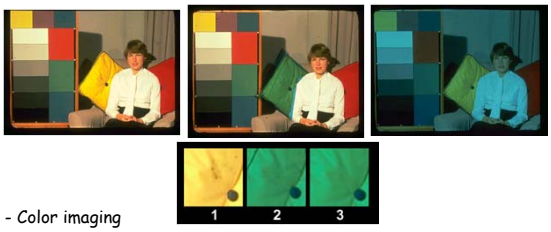
- Color imaging

Meccanismi per la costanza del colore

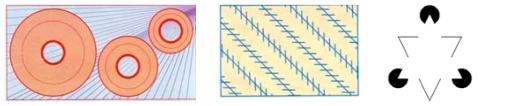


- Color imaging

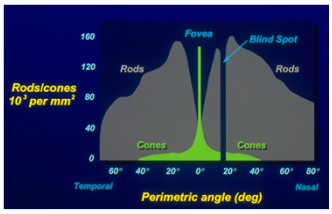
Meccanismi per la costanza del colore

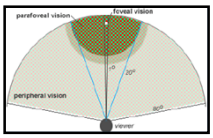


- Color imaging



Distribuzione dei coni e dei bastancelli



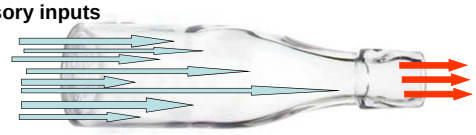


Massima risoluzione spaziale nella fovea, ottimizzata per la percezione dei dettagli.

- **Not all the information can be processed**
- **Attention: the process by which certain information is selected for further processing and the other information is**

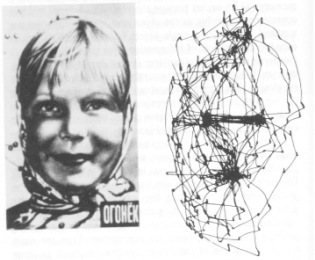
Numerous sensory inputs

Attended information



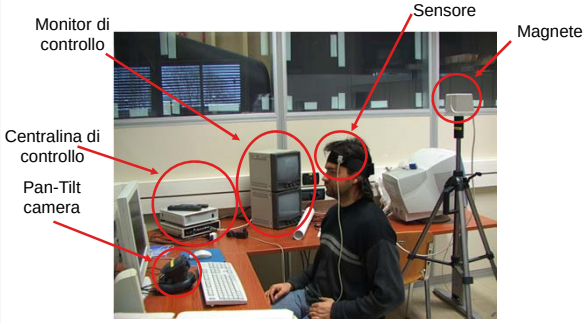
"Bottleneck": only a limited amount of information can be attended to

Meccanismi di attenzione



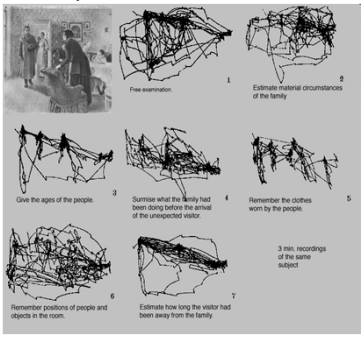
La maggior parte dei coni risiede nella fovea. La visione dell'uomo è quindi una visione attiva. Data una immagine, lo sguardo percorre dei cammini che hanno lo scopo di raccogliere l'informazione visiva. Questi cammini, esplorano soprattutto le zone con un alto contenuto di informazione visiva.

Meccanismi di attenzione



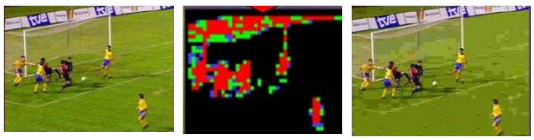
The most widely used are video-based eye trackers. A camera focuses on one or both eyes and records their movement as the viewer looks at the stimulus

This study by Yarbus (1967) is often referred to as evidence on how the task given to a person influences his or her eye movement.



Nicolas Poussin's "Rape of the Sabine Women," 1634, depicts a lot of action, yet it might seem somewhat static because it is so detailed

Meccanismi di attenzione

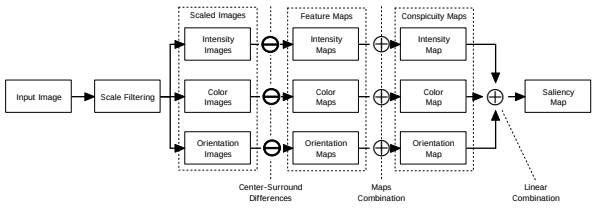


Applicazione dei meccanismi di attenzione alla compressione di immagini e video.

Figure 4. Automatic browsing of the example image.

Applicazione dei meccanismi di attenzione alla visualizzazione di immagini su smartphone.

Saliency Regions Detection

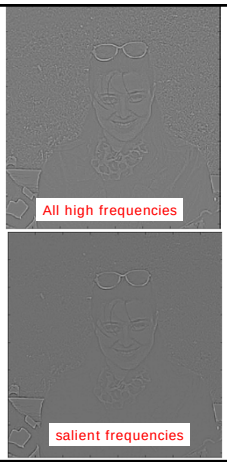


- L. Itti, C. Koch: "A model of saliency based visual attention of rapid scene analysis." IEEE Trans. on Pattern Analysis and Machine Intelligence, 20, 1254–1259 (1998).
- S.Corchs and G. Deco, "Large-scale Neural Model for Visual Attention: Integration of Experimental Single-cell and fMRI Data", Cerebral Cortex, Vol.12, pp. 339-348, 2002
- Our algorithm. Unpublished results

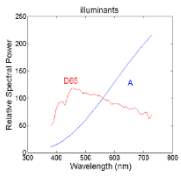
Saliency Regions Detection

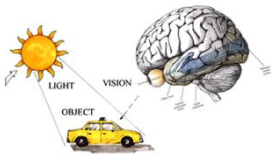
Original image with fixations

Saliency map

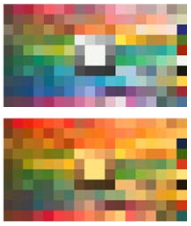


Adattamento cromatico





Macbeth Color Checker DC

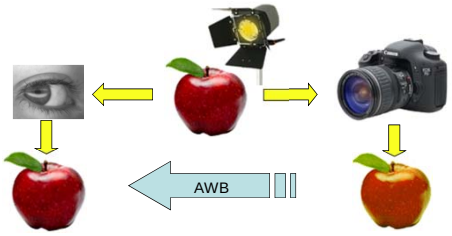


D65

A

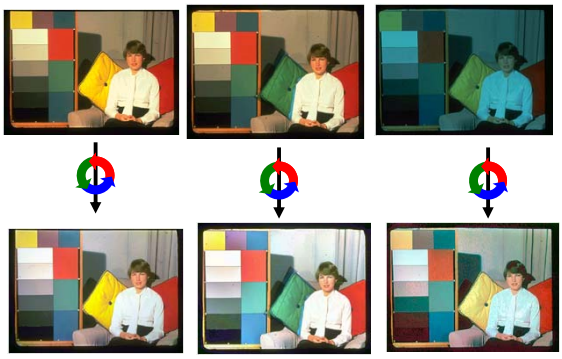
L'adattamento cromatico e l'abilità del sistema visivo umano di compensare il colore dell'illuminazione preservando approssimativamente l'apparenza dell'oggetto.

Algoritmi per la costanza del colore



Adattamento cromatico

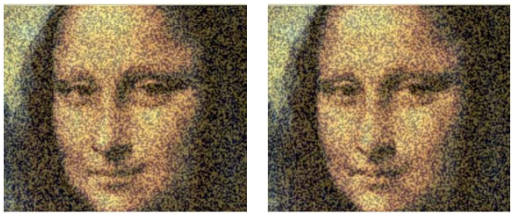
Algoritmi per la costanza del colore



Un piccolo esperimento

- Il rumore non degrada solamente la qualità delle immagini, a volte ne modifica il significato. Facciamo un piccolo esperimento:
  - Aggiungiamo all'immagine del rumore "random"
  - Facciamo N volte.
- Cosa otterremo ? Diverse immagini (di volti, in questo caso) che a priori potremmo considerare equivalenti. Ma e' vero?

Un piccolo esperimento



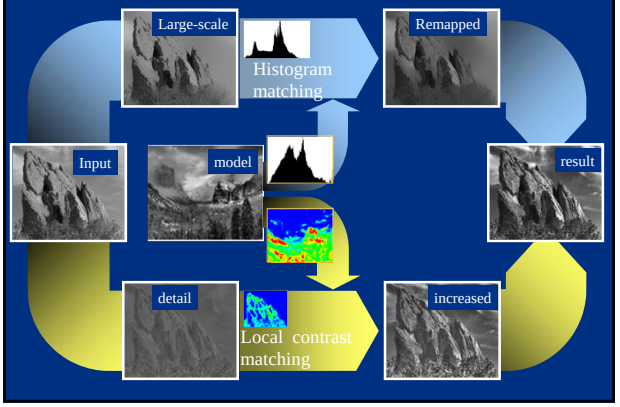
Due delle immagini ottenute

Basic denoising

Noisy input

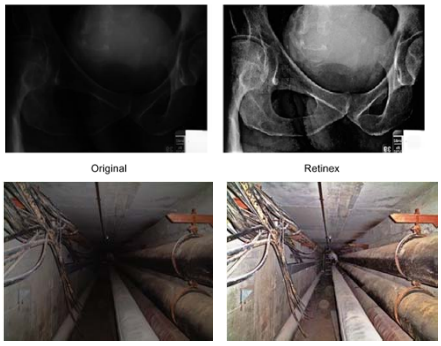
Bilateral filter 7x7 window

Two-Scale Style Transfer



Resa non foto-realistica

Esempi di Incremento del contenuto informativo



Esempi

http://dragon.larc.nasa.gov/viplab/projects/retinex/

Esempi

Esempi

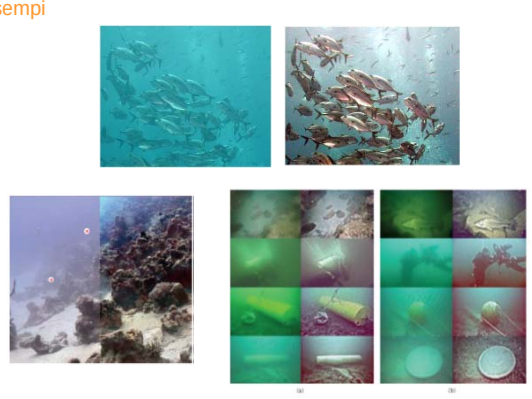


Image Enhancement for Visually Impaired

#101 20/400 (6/120) Central scotoma | Normal / No Simulation | As viewed through simulator

No Flash Photography

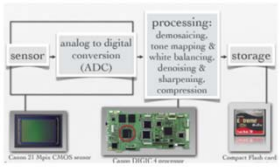
- Available light is not always enough, image is blurry/noisy

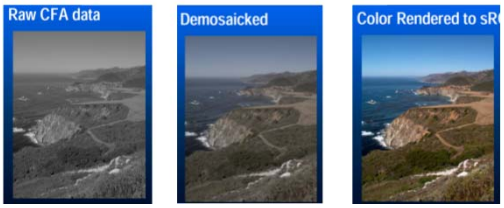
Flash Photography

- Available light is not always enough, image is blurry/noisy
- Flash photos look harsh, ambiance is not nice

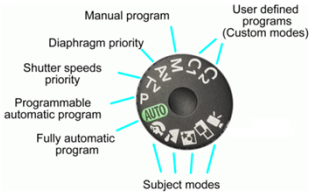
Flash / no Flash Photography

- Available light is not always enough, image is blurry/noisy
- Flash photos look harsh, ambiance is not nice
- Combines the two to get the best of both

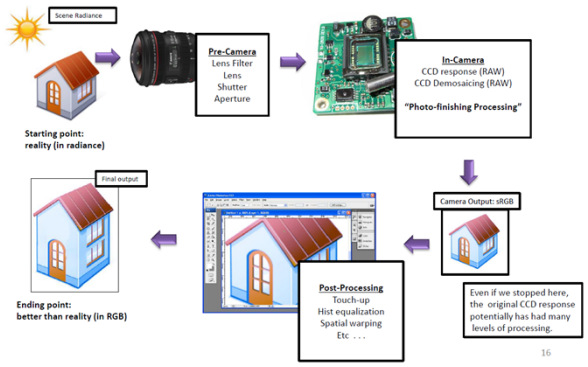




Light-measuring device?

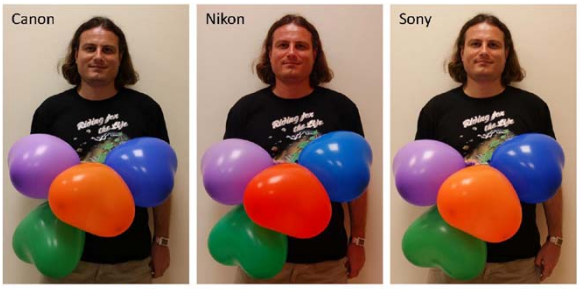


Modern photography pipeline



16

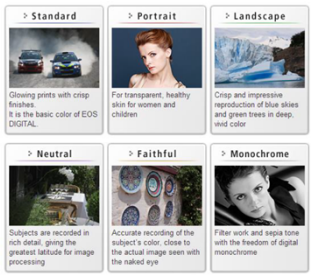
Post-processing

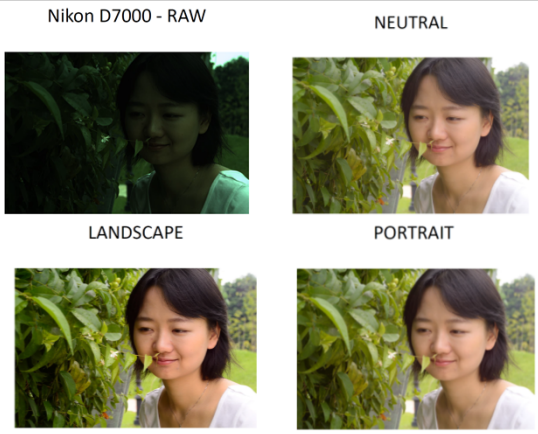


Three different cameras with **same aperture**, **exposure**, **white-balance** and **picture style**, etc. . .

Post-processing

Camera "styles"



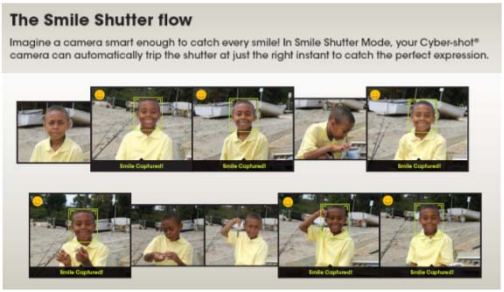


Face detection and tracking

Other possible uses of face/smile detection

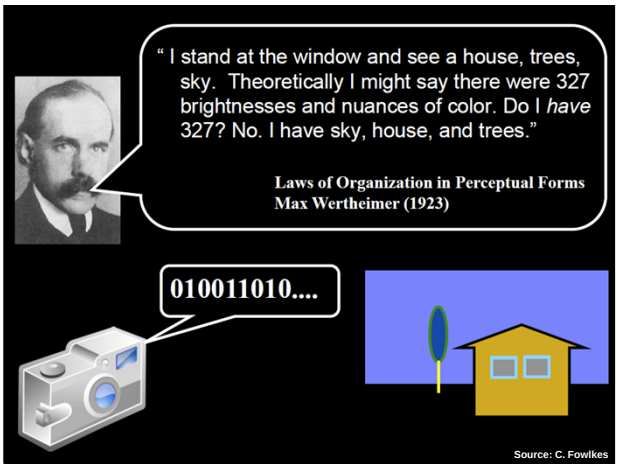
http://www.fotonation.com/

Smile detection?

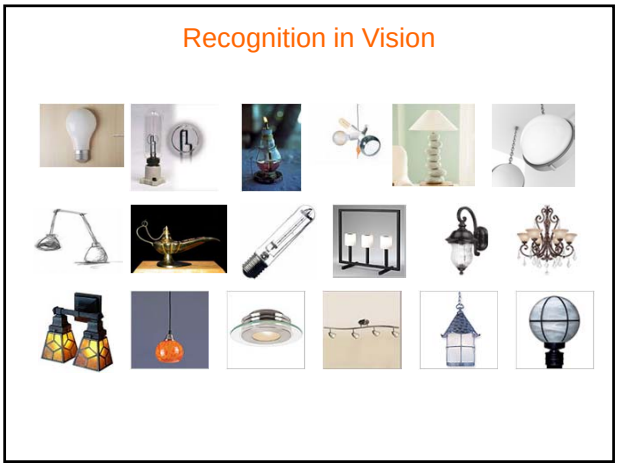


Sony Cyber-shot® T70 Digital Still Camera

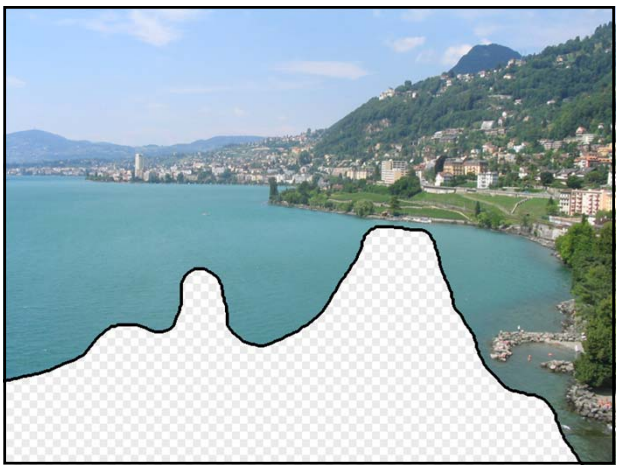
Source: S. Seitz

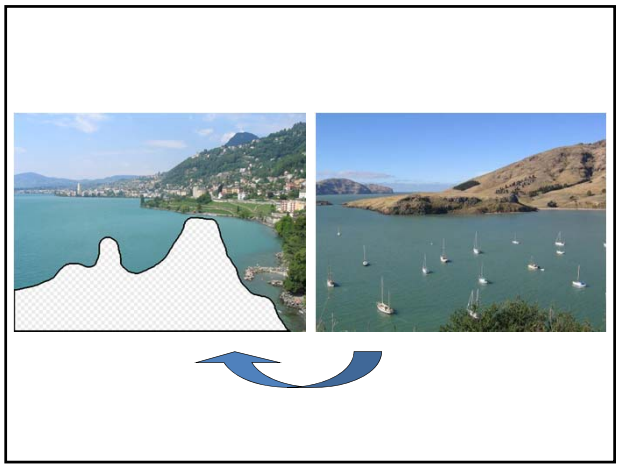

" I stand at the window and see a house, trees, sky. Theoretically I might say there were 327 brightnesses and nuances of color. Do I *have* 327? No. I have sky, house, and trees."
Laws of Organization in Perceptual Forms
Max Wertheimer (1923)
010011010....
Source: C. Fowlkes


But…we have 10000 to 30000 object categories
Biederman, 1987
Slide by Aude Oliva

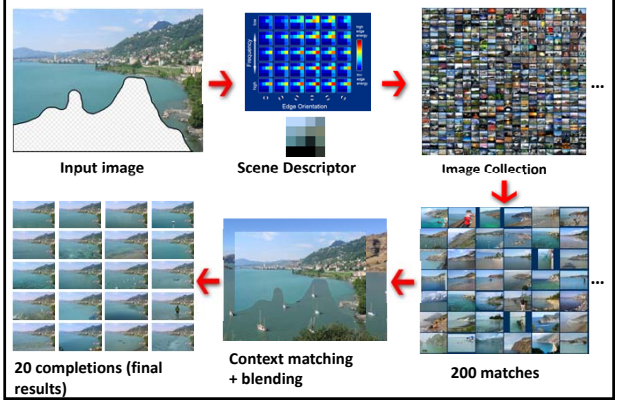

Recognition in Vision

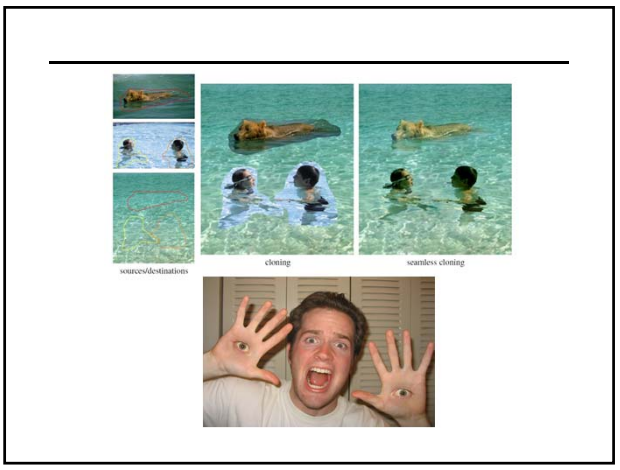

http://www.paulridenour.com/Obama14.JPG





The Algorithm

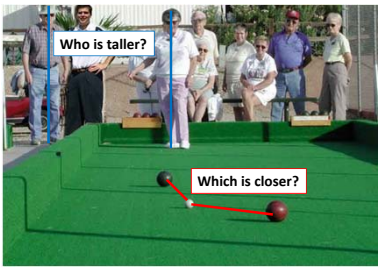




Projective Geometry

What is lost?

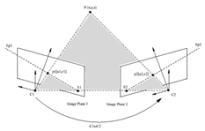
- Length

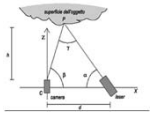


3D face recognition

- Hard to circumvent

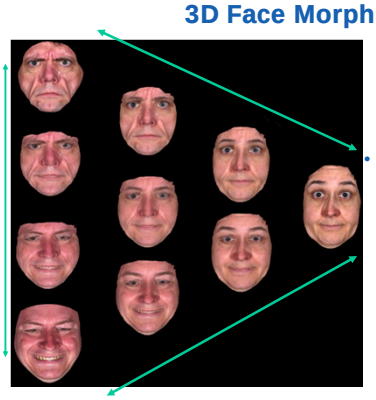
3D acquisition devices



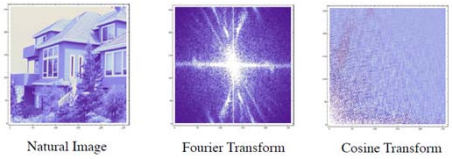


3D Face Morphing

3D Face Morphing



- Morphing between two or more faces

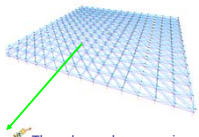
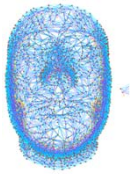


Estrazione di caratteristiche


On the left: the "real" Miss Germany 2002 (= Miss Berlin) and on the right: the "virtual" Miss Germany, which was computed by blending together all contestants of the final round and was rated as being much more attractive.

Imaging and Vision

Facile: 3D Face animation

Piecewise linear and sphincter muscles;

Three-layered mass spring system for skin;

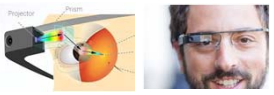
Face model

Facile: a physical model of face dynamics

Facile allows the of facial expressions synthesis; and facial expression transfer.

3d imaging using Kinect

Imaging and Vision

Imaging and Vision

DISCo - Multi touch virtual table

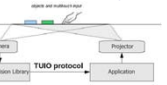


2009

2010

Interactive virtual objects

201... ?



Imaging and Vision

1M CCTV cameras in London & 4M in U.K.; average Briton is seen by 300 cameras/day; 400K cameras in Beijing provide 100% coverage of public places; 150K cameras in Seoul

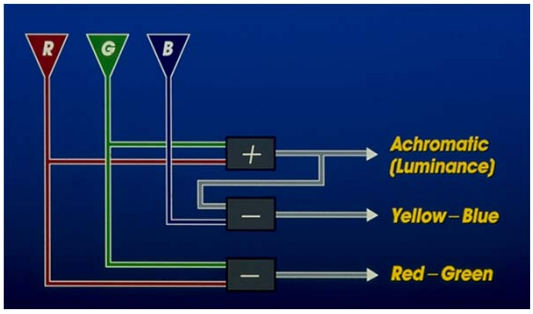
- Vision is useful: Images and videos are everywhere!

Source: L. Lazebnik

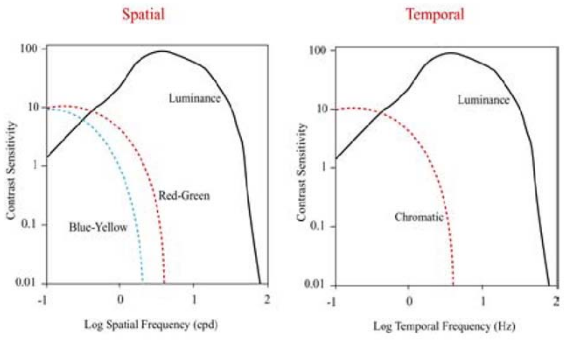
Modelli della visione e fotografia digitale

R. Schettini
D.I.S.Co. (Dip. Informatica, Sistemistica e Comunicazione)
Università degli Studi di Milano-Bicocca,
Viale Sarca 336, 20126 Milano Italy
ww.ivl.disco.unimib.it

Compressione del segnale retinico e compressione delle immagini

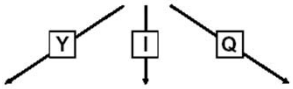


Compressione del segnale retinico e compressione delle immagini



Compressione del segnale retinico e compressione delle immagini

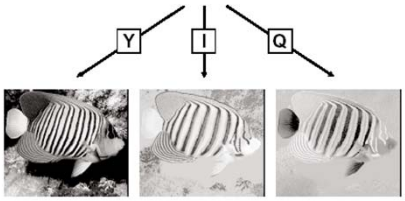
Target display image is RGB, derived from camera



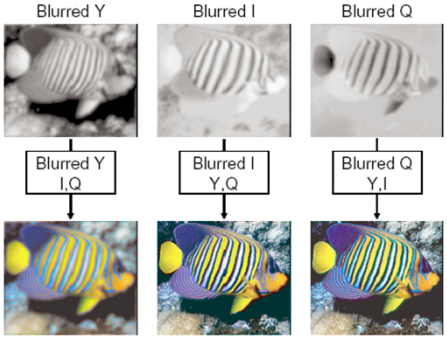
For transmission in the US, the image is converted into YIQ

Compressione del segnale retinico e compressione delle immagini

Target display image is RGB, derived from camera



Compressione del segnale retinico e compressione delle immagini



Compressione del segnale retinico e compressione delle immagini