Digital Image Processing Lecture 2

The human visual system, perception, and color

Throwback to highschool biology

The cornea is the clear part covering everything, all of your eye, it's clear so that the pupil and iris are visible.

The iris is the 'color' part of the eye. The iris expands and contracts acting as an aperture to allow light into the pupil only the front of the iris is in color.

+ behind the iris is the lens, - A hard - Jelly - like blob of material. The lens focuses the light onto the Retina.

+ The retina is where all of the light sensitive cells are located. (these are where the rods and cones are)

+ there is this special part of the retina called the fovea. The fovea is the central part of the retina, this is where the highest concentration of cones (color sensitive cells) live.

→ fovea: the only part of the eye that defines what seems to be in focus.

there is a part that's in focus and there is a peripheral vision not in focus.

→ Behind is the optic nerve, This carries the signals from the rods and cones back to the brain.

2.1.1 Structure of the Human Eye

Figure 2.1 shows a simplified horizontal cross section of the human eye. The eye is nearly a sphere, with an average diameter of approximately 20 mm. Three membranes enclose the eye: the *cornea* and *sclera* outer cover; the *choroid*; and the *retina*. The cornea is a tough, transparent tissue that covers

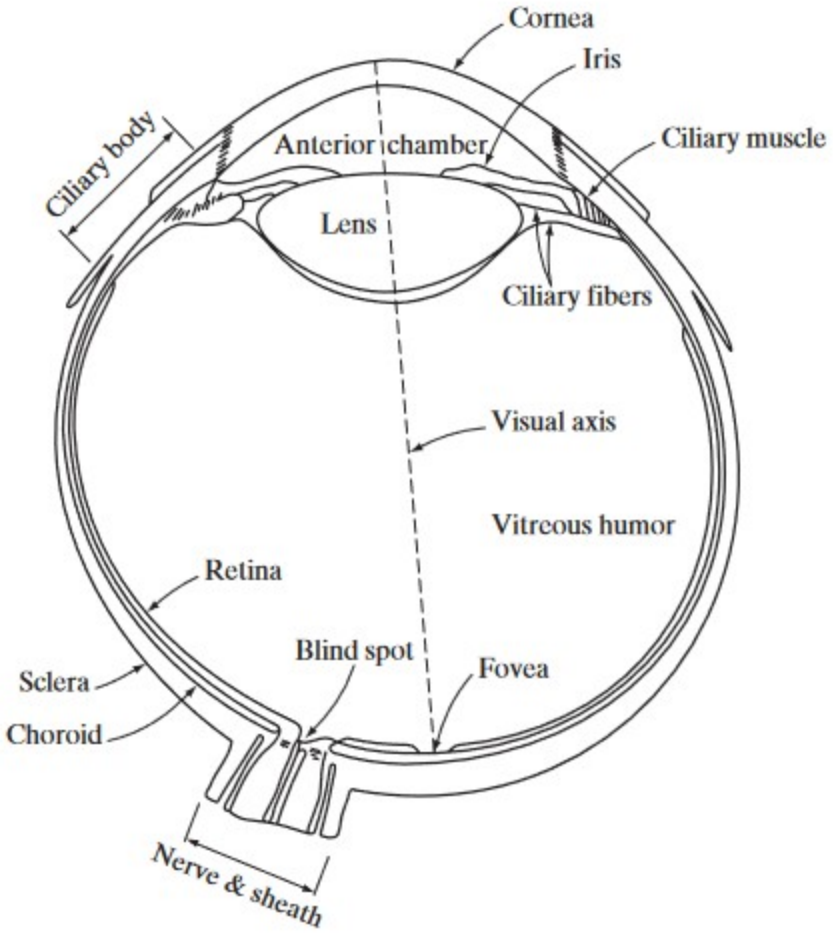


FIGURE 2.1 Simplified diagram of a cross section of the human eye.

(B) When the optic nerve connects to the eye, there ~~is~~ are no cones or rods. (WE CALL This the blind SPOT)

→ A Thought experiment (Not an experiment)
There is a region on the Retina with no photo sensitive cells. Your brain is filling the details.

<u>Cones</u>: colour sensitive cells
<u>rods</u>: light sensitive cells.

Size of ~~FOW~~ FOVEA: 1.5 mm square
350K INDIVIDUALLY ADDRESSIBLE
color-sensitive receptors

→ So Radke states: there 350K "pixels" packed in your eye, — ~~that number of pixels is crappier than the~~
— So is it true ~~that~~ the number of pixels is lower than a crappy digital camera?

→ So why does the world seem so much richer?
There is a lot more going on.

Your brain is using a lot of past experience and (major recognition system at play) → some complicated filters.
The information your eye gets is not mapped directly to what you <u>perceive</u>.

there isn't a lot of raw information ~~that~~ is received by your Retina, but you are getting a rich visual experience

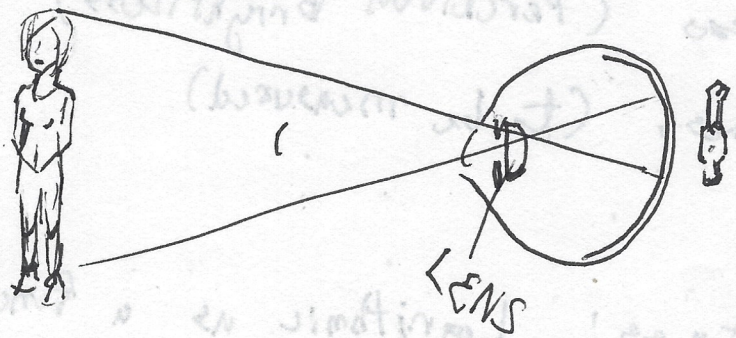


Image on the Retina
→ your brain flips it right side up.

→ Not exactly what a camera does

→ the camera can adjust the aperture with a good ~~DSRL~~ DSLR camera with a focal lens

→ when you turn the ring, you are physically moving the distance between the CCD and the ~~camera~~ camera ~~&~~ and the aperture (hole where the light goes through)

↓ like one object

your eye cannot move back and forth the iris with respect ~~to the~~ Retina

→ Idea! Your lens is not a hard piece of glass

Your lens physically changes shape, flattens or thickens

looking at my computer screen and then looking at ~~my~~ the bathroom door, My focus changes, my lens is changing.

(4)

Brightness

the eye has a huge dynamic range

① (10^{10})

Subjective Brightness (Perceived Brightness)

Objective Brightness (to be measured)

INCIDENT

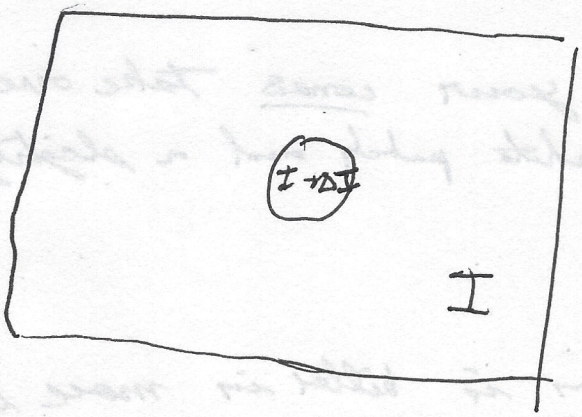
Subjective Brightness: Logrithmic as a function of Intensity

you cannot perceive this simultaneously, if in a bright room, you can't see the details in the shadows

→ your eye can adjust to dark room, after some time you can see details (shape of objects) ~~that~~ the level of intensity of photons can be very low compared to what you perceive.

Brightness ADAPTation. the Iris opens / closes to (Let in) / Restrict An Amount of light.

SAY for an experiment, you have a uniform gray rectangle, with uniform intensity I, (Shade of gray)



There is a circle in the center with a different shade of Intensity

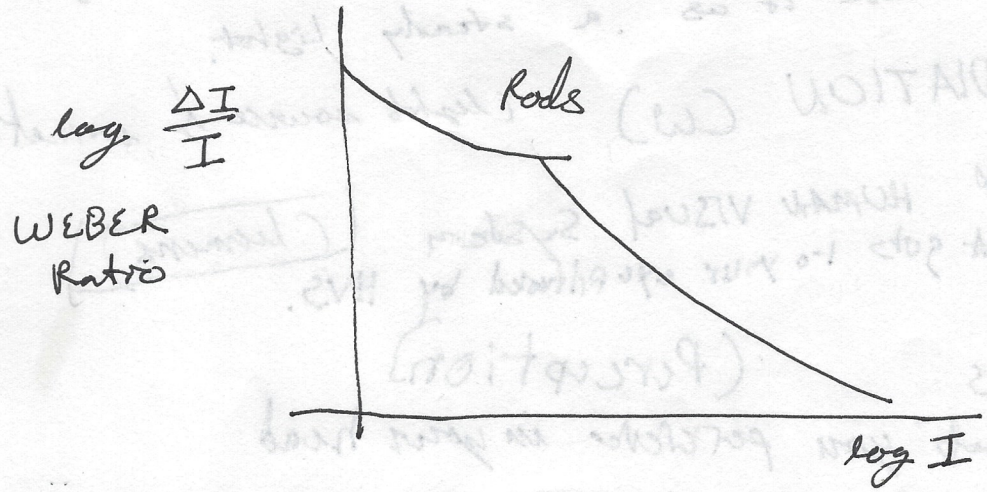
For the center, lets add and remove ΔI so that when it's removed, the center has the same intensity as the rectangle.

Add and Remove at a certain rate,

After some time, ask the subject, "At what point does the Image look like a steady Image?"

- You might perceive the Image as a constant intensity, I
- If your perception is good, then you can see the difference.

→ "Just noticable difference" → leave it on till the difference is not noticable



⑥ It's hard to know the Intensity when you are in a dark room. (Action of the rods)

→ when in a brighter room, your cones take over
→ It's more easy to define a white patch and a slightly less white patch.

Takeaway, brightness adaptation is better in more light and worse in less bright (Dark) situations.

MACHBAND Phenomenon → www.michelbach-delot/

these psycho physical phenomenon is a reason why digital compression works.
23:00

CRITICAL FUSION Frequency
Say there is a blinking Light, if the Light is blinking Fast enough - you perceive it as a steady Light.

EMITTED RADIATION (W) (light source is emitting)

FILTERED BY HUMAN VISual System (Lumens)
light that gets to your eye filtered by HVS.

Brightness (Perception)
← that you perceive in your head

There two kinds of light sensitive cells in the eye, rods & cones

RODS

* very sensitive to Light INTENSITY

* NIGHT "scotopic" vision

* Rods are responsible for your night vision
Anything you can see in the dark is due to the Rods.

* ACHROMATIC
(Not SENSITIVE to Light)

* LOW ACUITY
(Many per nerve end)
The information from many rods at once are being aggregated and carried by a single nerve

* Responsible for Duriphoral vision

* Slow Response to Light
(they are sensitive to light but have a slow response)

75-150 M / Retina

CONES

* only sensitive to direct light
"PHOTOPIC" Vision

recall, cones are super concentrated in the fovea
(fovea is part of the ~~Rat~~ Retina receiving direct light)
Rods are not in the fovea, they do not recieve direct sunlight
- cones are in the fovea because that is where they are most effective.

* CHROMATIC (3 "colors")
(the respond to 3 different colors)

* concentrated in fovea
(1 per nerve ending)

You are getting a lot more information from the cones than from every single rod.

* HIGH visual Acuity, Spatial Resolution

* Fast response to Light

6-7 M / RETINA

(8) An Important NOTE is that the peripheral vision has color, Why so? Especially if there are so few cones that receive the vision of peripheral? → The brain is picking up the slack and filling in the blanks

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CONES ENABLE color Perception

3 TYPE long medium and short based on wavelength

L sensitive To "RED" ← Actually more Yellow-Green 65%

M sensitive To "GREEN" ← Actually more Greenish blue 33%

S sensitive to "BLUE" ← Actually more Bluish-Purple 2% (MOST SENSITIVE)

ratio of $\frac{L}{M}$ varies quite a bit on the person by person basis.

- fact L and M cones are on X chromosome
  So if something happens on the X chromosome, A Man is more likely to get it → Problems with the X chromosome, that's where color blindness comes from.

- fact color blindness comes from the inability to distinguish between these two types of cones
  → Medium cones are more likely, You have trouble distinguishing from Red, yellow and green.
  5% of Men are colored-blind (this type of blindness) (Women are never colored blind) (Women may have more types (4) of cones)

Animals have different types of cones

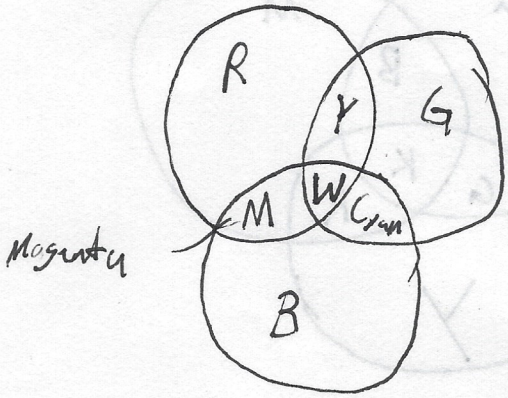
CIE STANDARD (wave length)

R 700 nm
G 546 nm
B 436 nm

STANDARD
Primary colors

→ IMAGE capturing devices (cameras)
IMAGE recreation devices (Monitors / TVs)
They yeild to this standard
They attempt to capture and combine responses/emissions of these primitive colors.
So all TVs should know what Green, Red, and Blue should be.

→ SMART LIGHTING URPs This Semester?



IN MATLAB, we have a Digital IMAGE where every pixel has ~~any~~ an RGB value

	R	G	B
Red	[1	0	0]
Yellow	[1	1	0]
White	[1	1	1]

scale from 0 to 1, sometimes matlab uses 0 to 255