http://www.mcescher.com/Biography/lw439f14.jpg

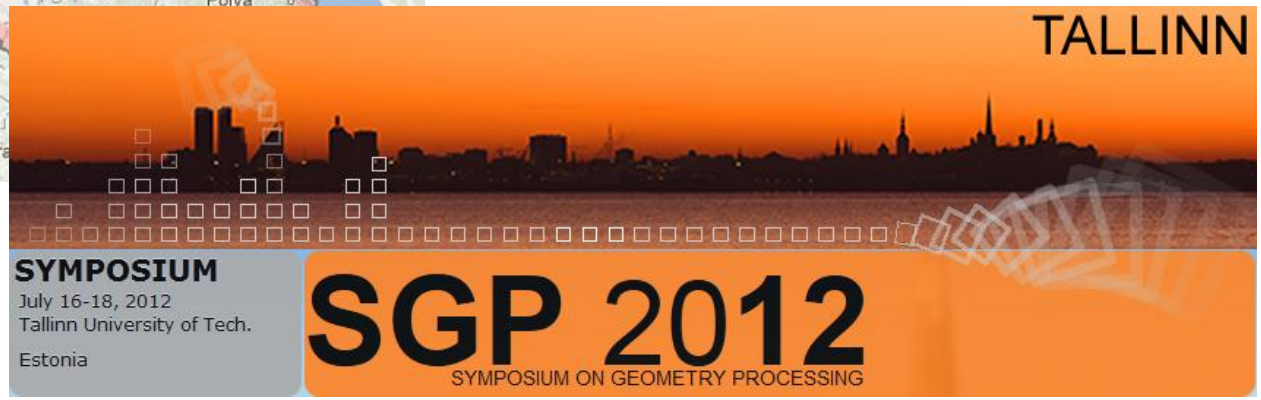
Perception

CS 148, Summer 2012
Introduction to Computer Graphics and Imaging

Justin Solomon

<aside>

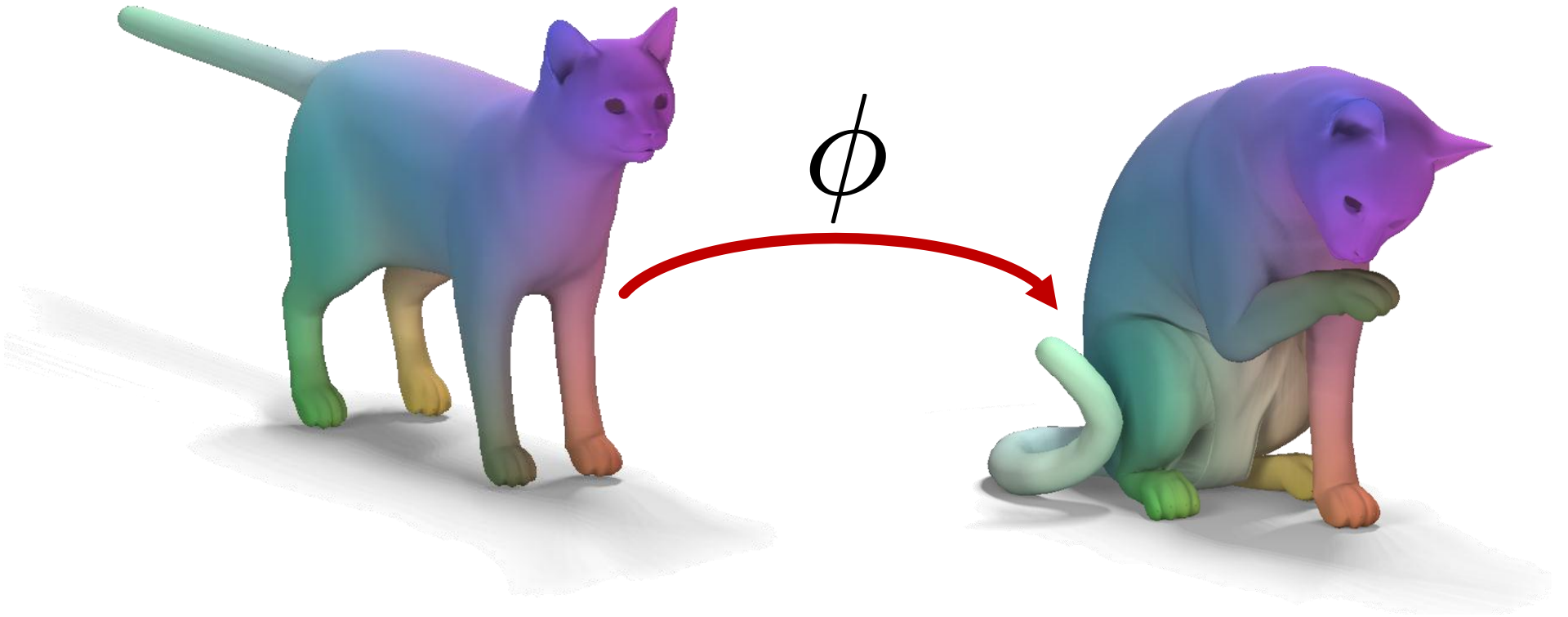
Where I'll Be …



Symposium on Geometry Processing

Where I'll Be …

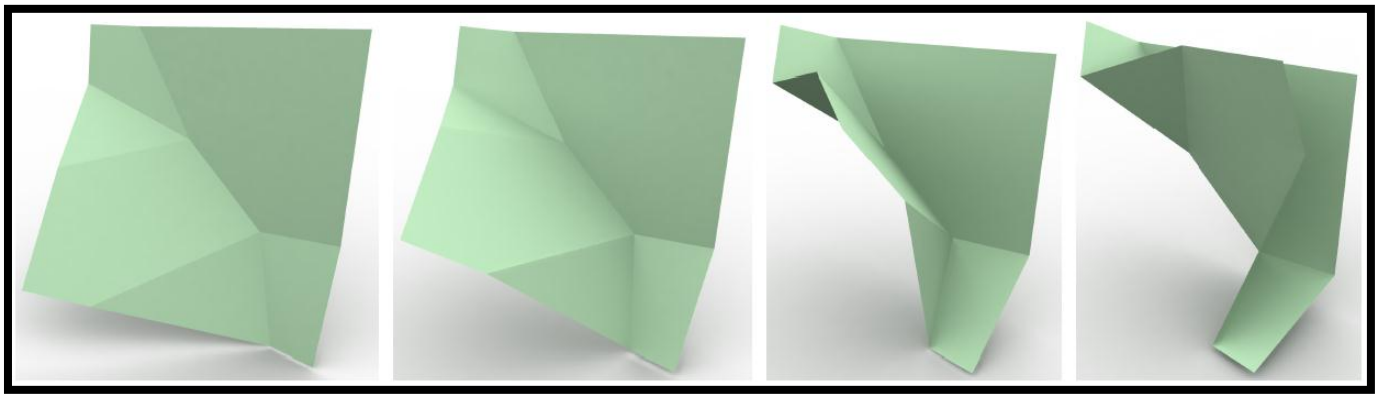
Three talks!

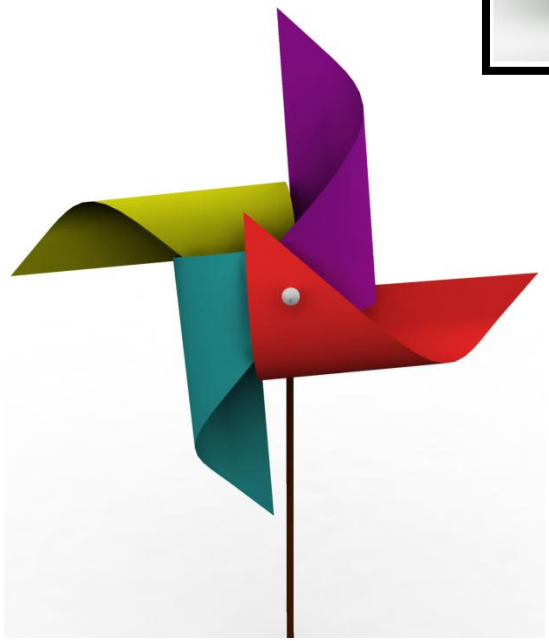


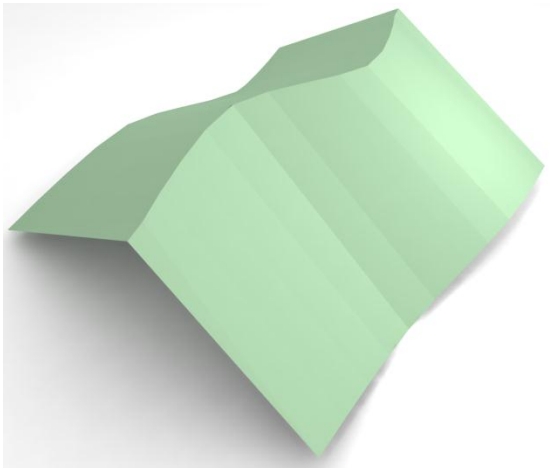
Intro to Shape Analysis and Correspondence

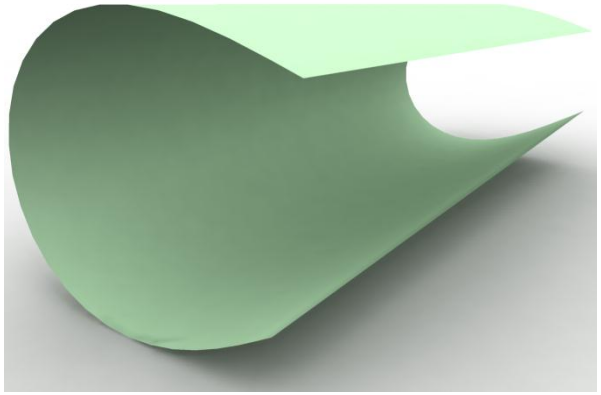
Where I'll Be …

Three talks!







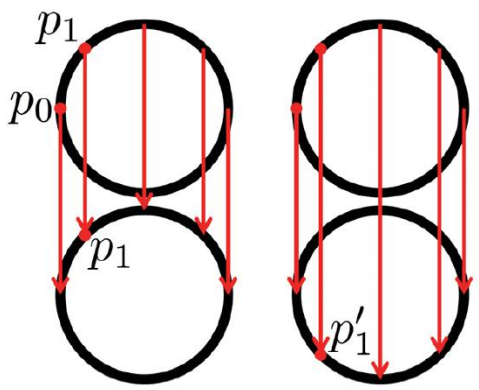


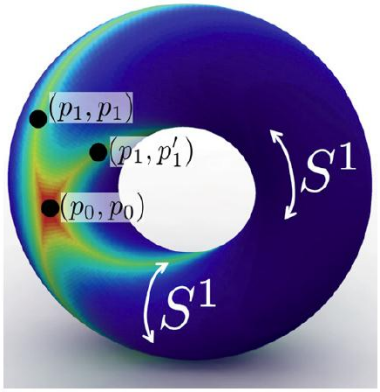
Flexible Developable Surfaces

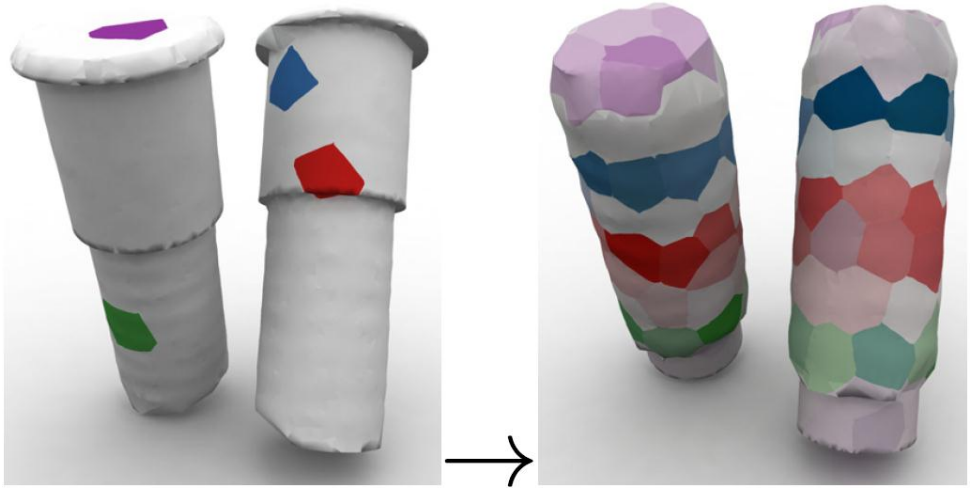
with E. Vouga, M. Wardetzky, and E. Grinspun

Where I'll Be …

Three talks!







Soft Maps Between Surfaces

with A. Nguyen, A. Butscher, M. Ben-Chen, and L. Guibas

Guest Lectures in CS 148

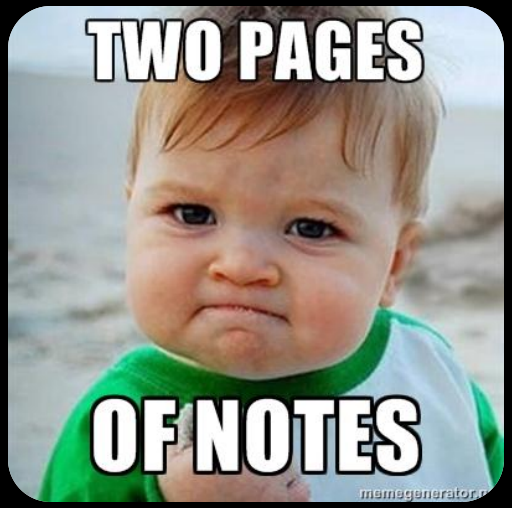
Qi-xing Huang

Light and Color
July 13

Katherine Breeden

Shading, Texturing, and Materials
July 16

Will be covered on the midterm!



July 18, in class

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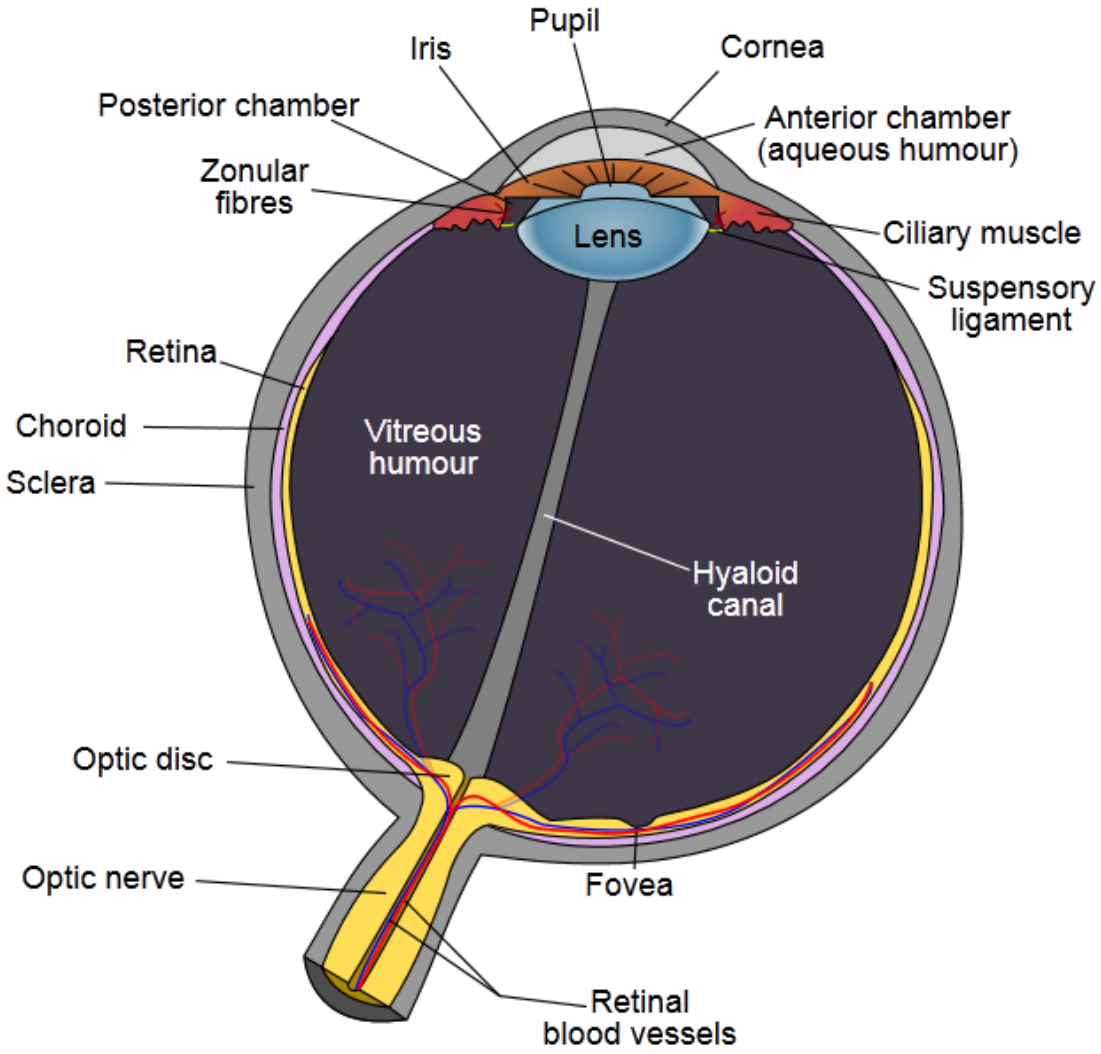
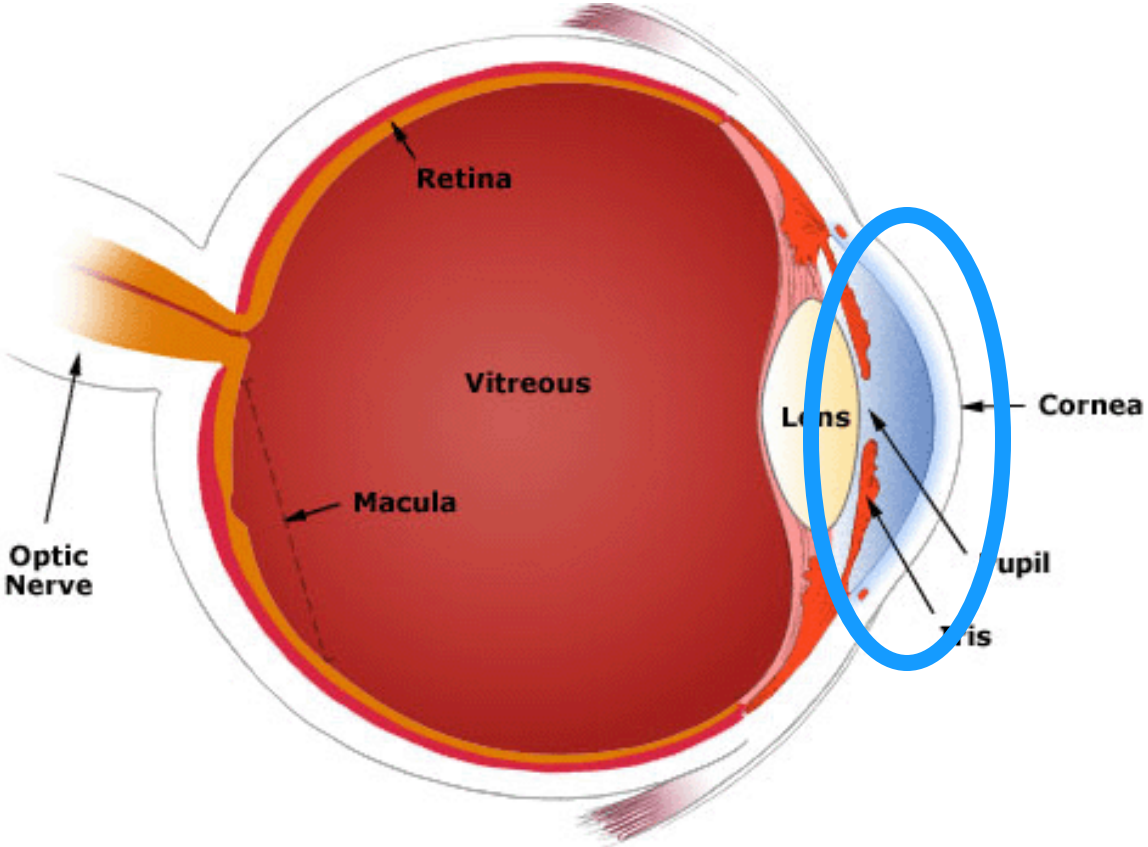
Our Main Client



http://upload.wikimedia.org/wikipedia/commons/1/1e/Schematic_diagram_of_the_human_eye_en.svg

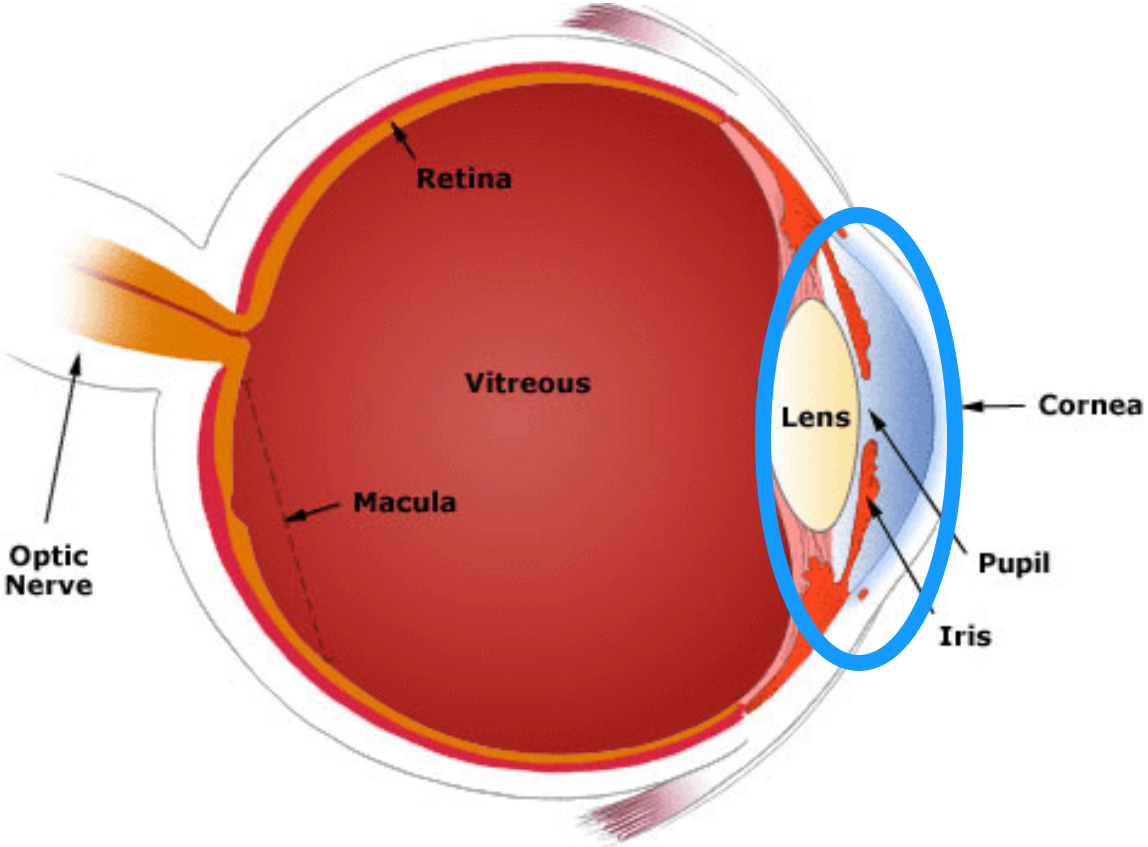
How the Eye Works



http://www.clearvieweyes.com/images/howEyeWorks.gif

Cornea: Fixed-focus lens

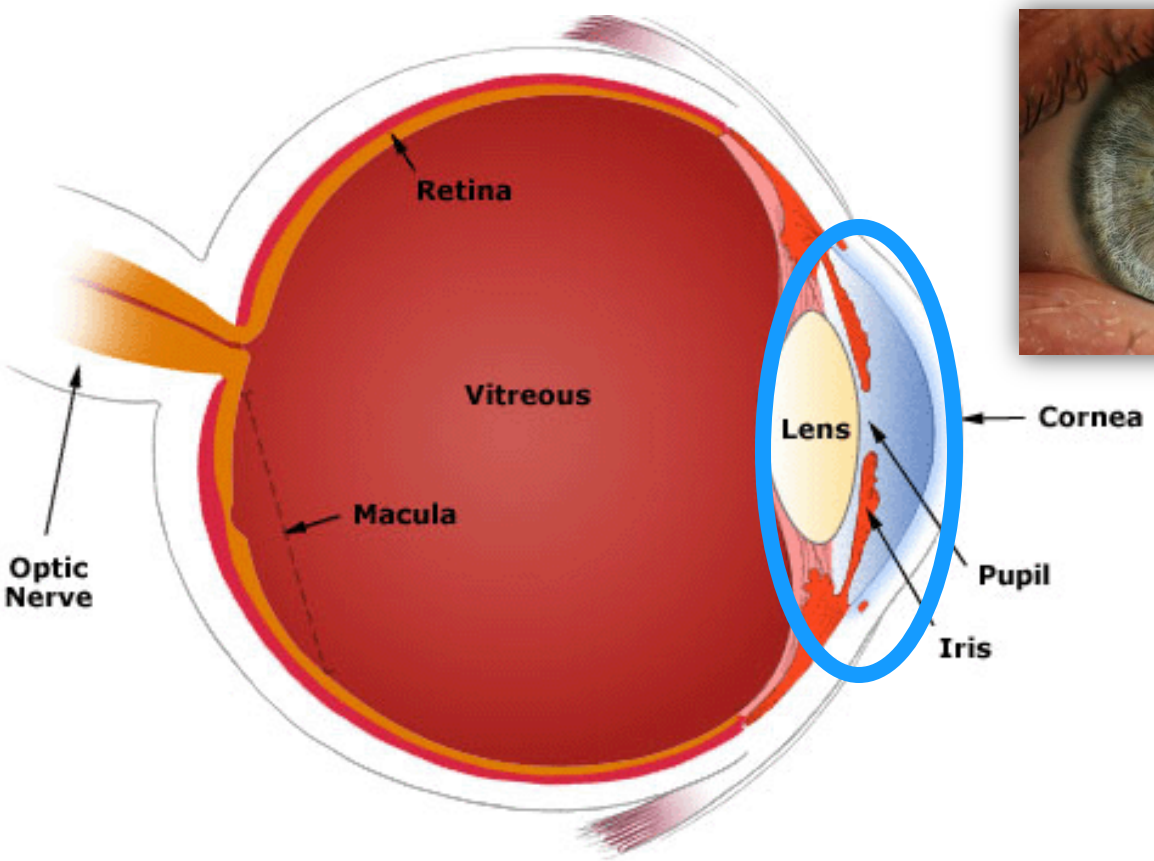
How the Eye Works

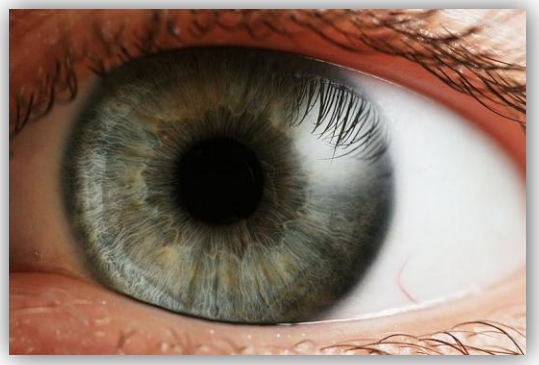


http://www.clearvieweyes.com/images/howEyeWorks.gif

Pupil/iris: Adjustable opening

How the Eye Works

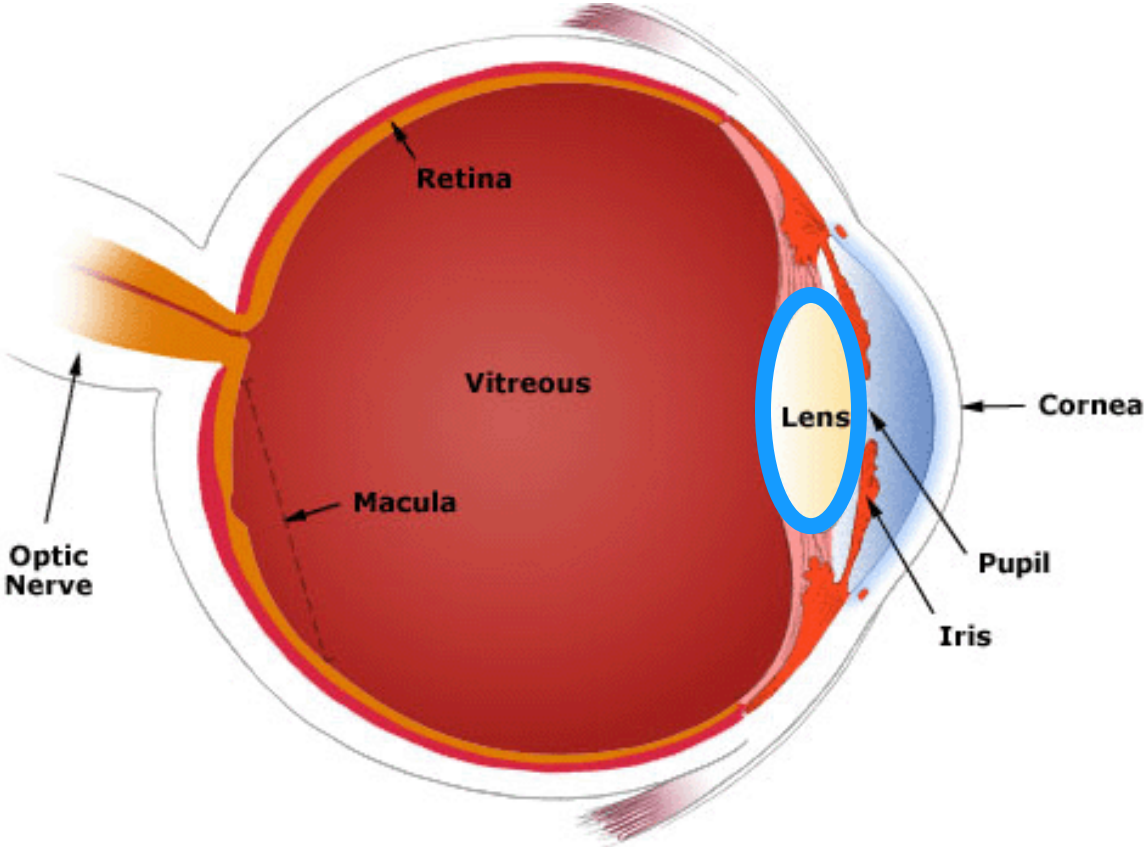




http://www.clearvieweyes.com/images/howEyeWorks.gif

Pupil/iris: Adjustable opening

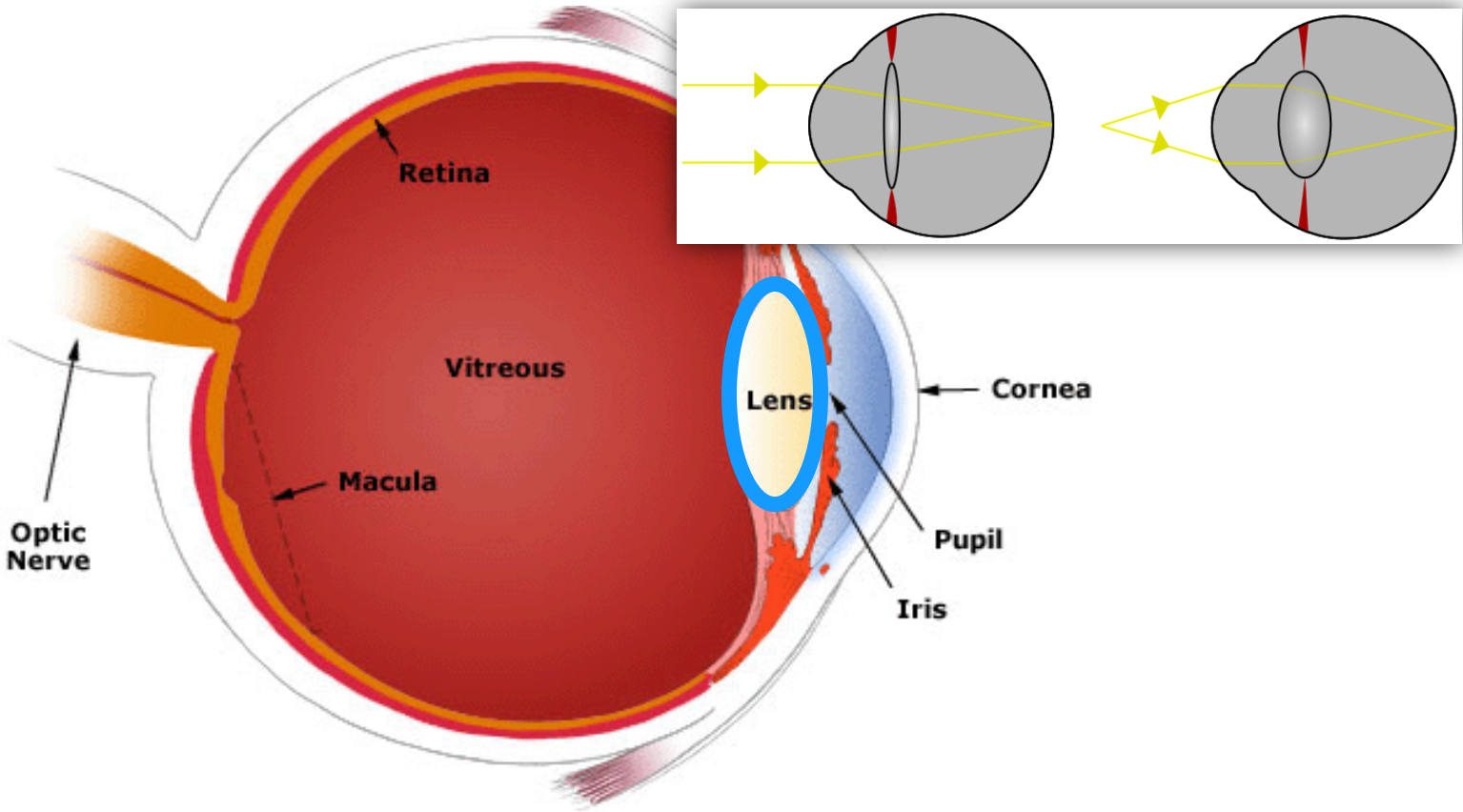
How the Eye Works



http://www.clearvieweyes.com/images/howEyeWorks.gif

Crystalline lens: Adjustable

How the Eye Works



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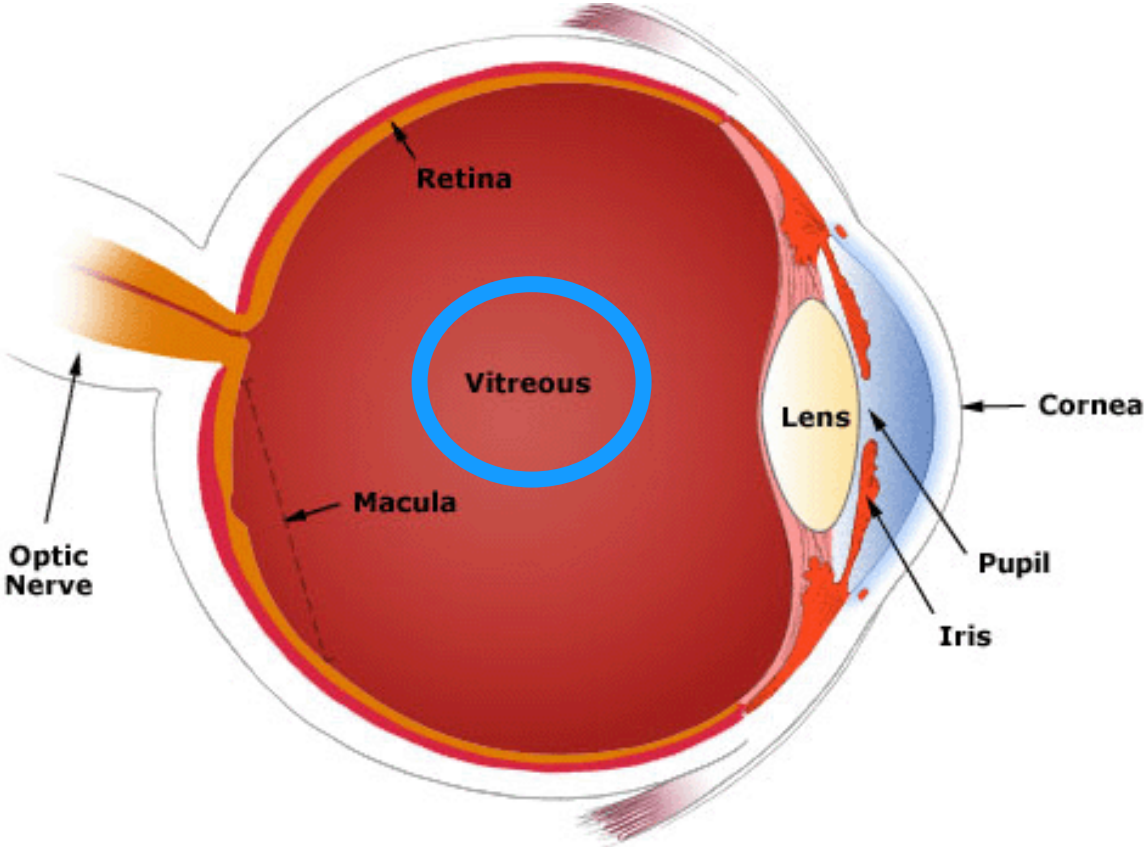
Crystalline lens: Adjustable

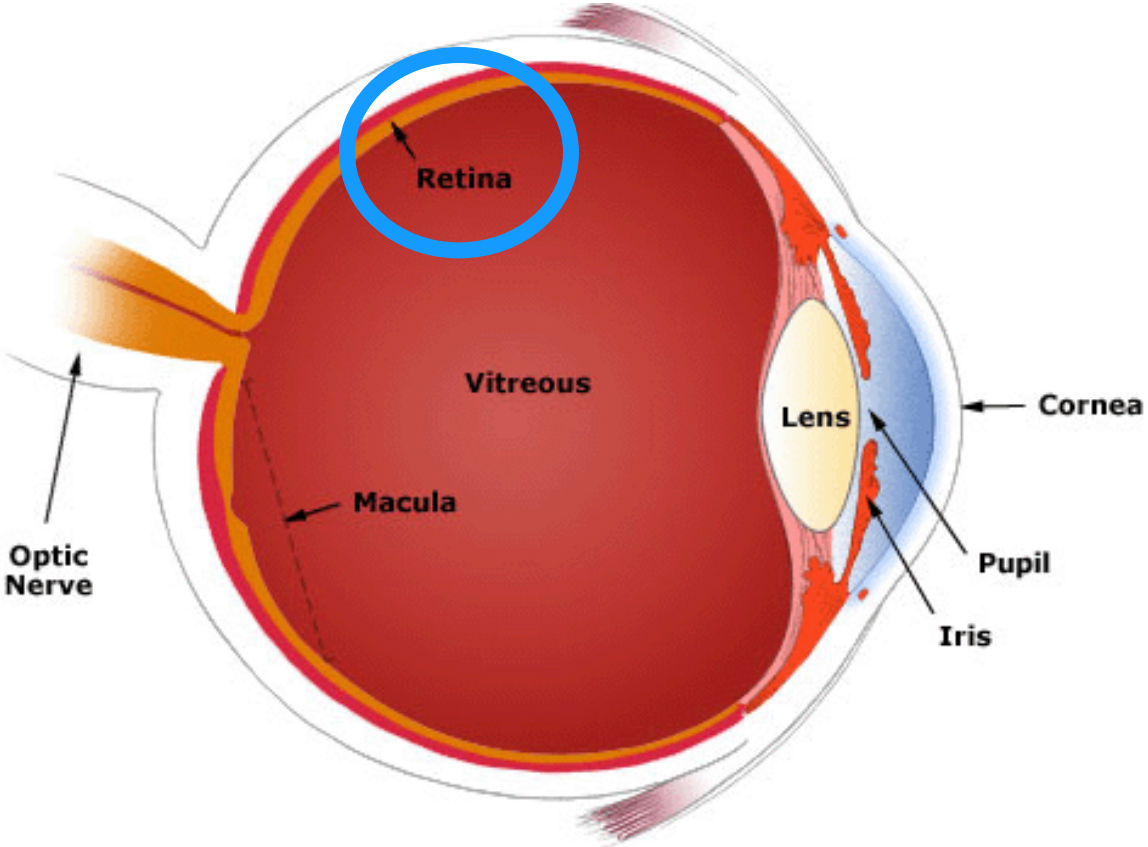
How the Eye Works



http://www.clearvieweyes.com/images/howEyeWorks.gif

Vitreous humor: Goo

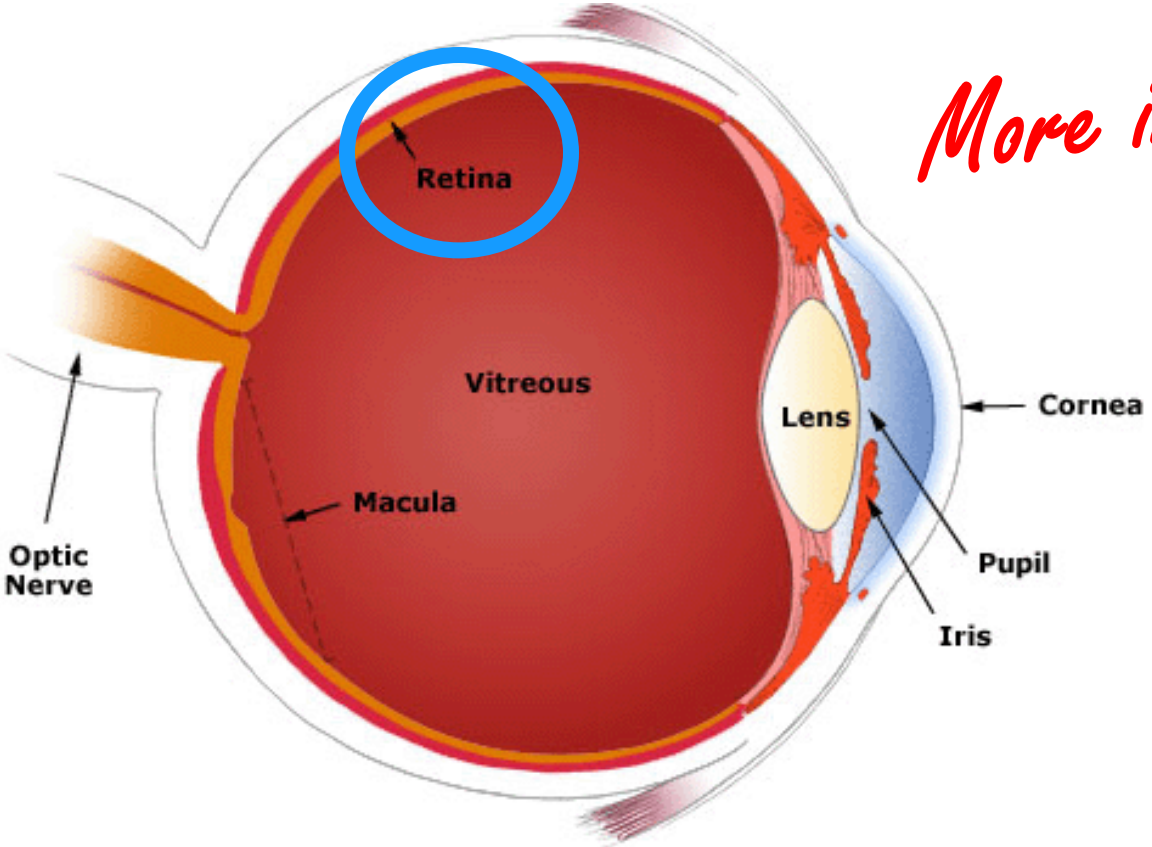
How the Eye Works



http://www.clearvieweyes.com/images/howEyeWorks.gif

Retina: Photo receptors

How the Eye Works

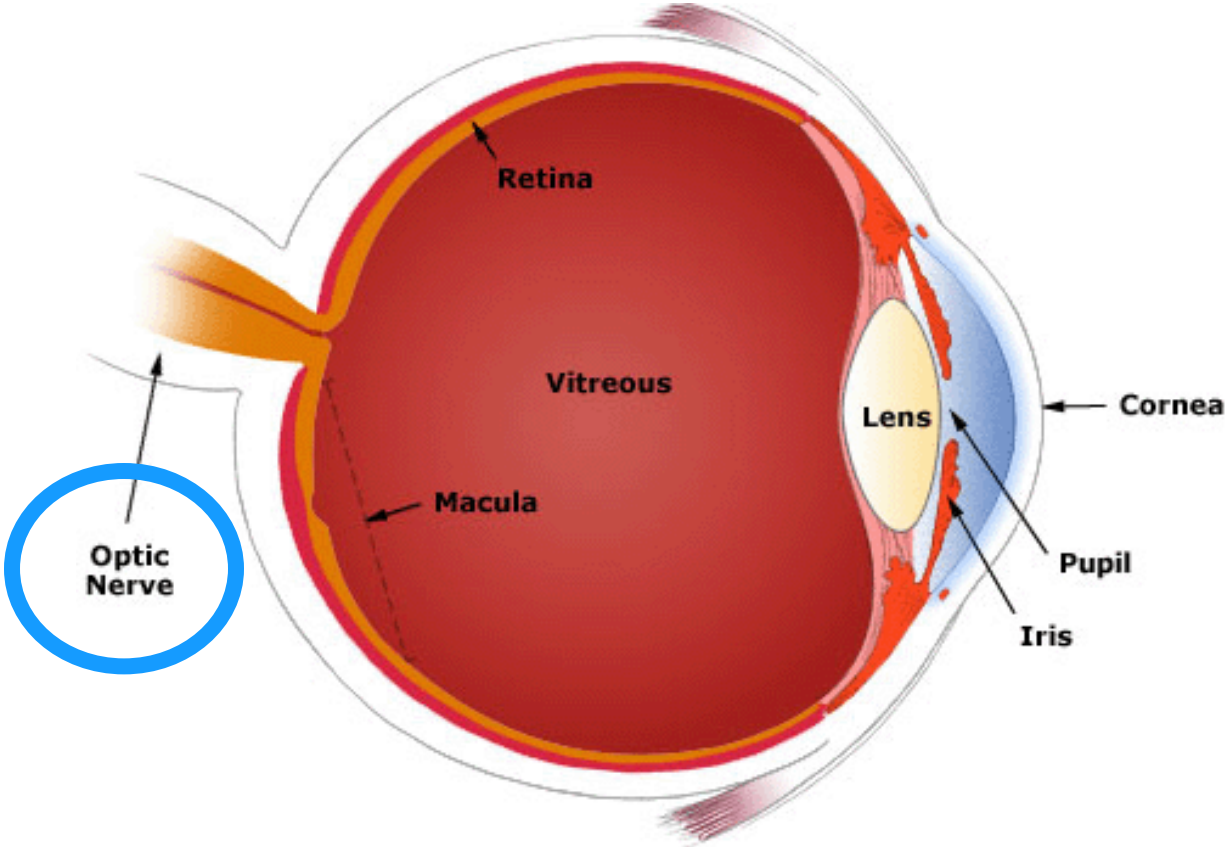


More in a second!

http://www.clearvieweyes.com/images/howEyeWorks.gif

Retina: Photo receptors

How the Eye Works



http://www.clearvieweyes.com/images/howEyeWorks.gif

Optic nerve: To brain

How the Eye Works

Eye converts light signals to chemical ones

http://www.clearvieweyes.com/images/howEyeWorks.gif

Optic nerve: To brain

How the Eye Works

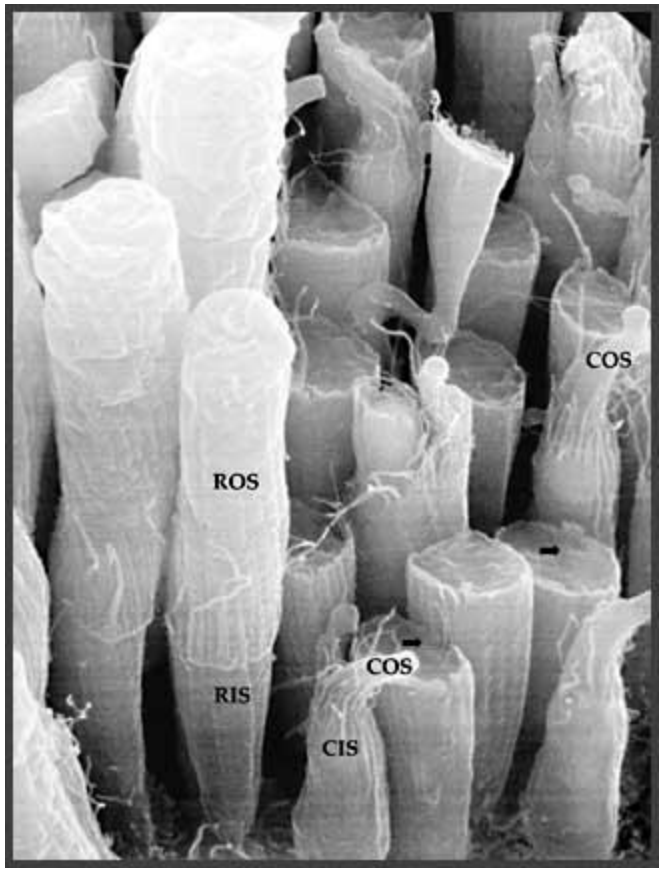
Eye converts light signals to chemical ones

More when we discuss physics of light!

http://www.clearvieweyes.com/images/howEyeWorks.gif

Optic nerve: To brain

Rods and Cones



Rods:

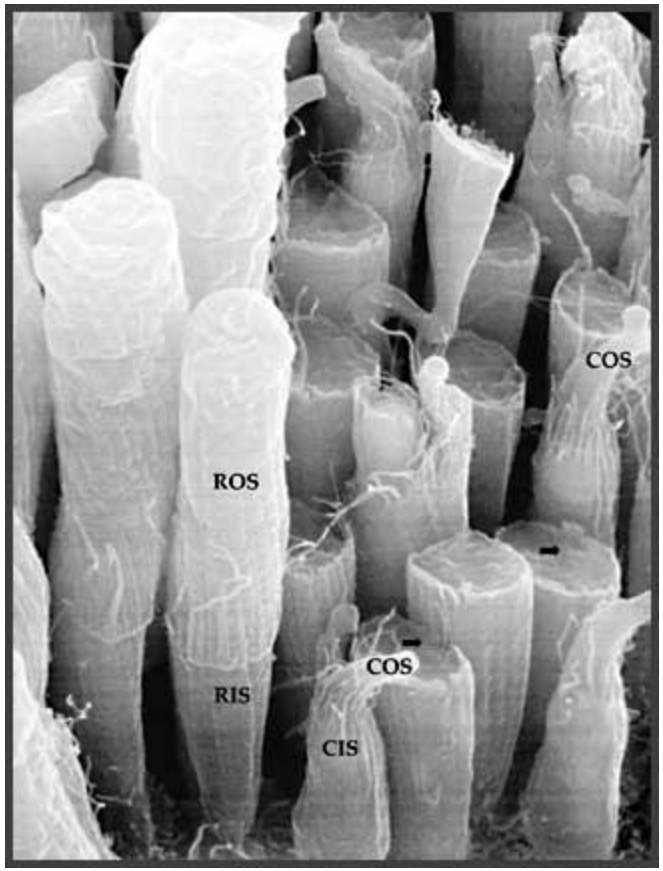
Sensitive to light energy

Cones:

Sensitive to color

http://hamwaves.com/antennas/diel-rod/rods_cones.jpg

Rods and Cones



Rods: *More*

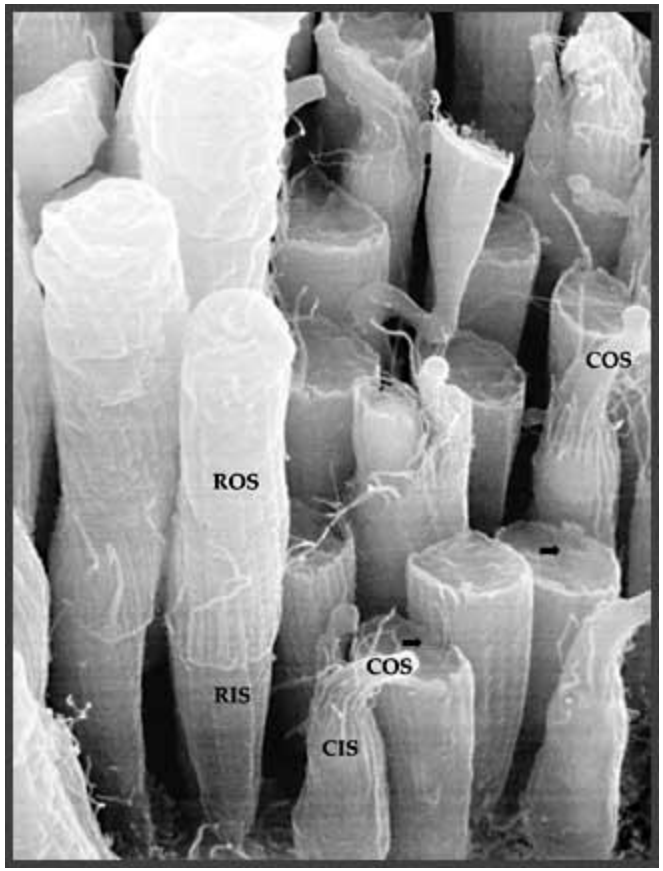
Sensitive to light energy

Cones: *Fewer*

Sensitive to color

http://hamwaves.com/antennas/diel-rod/rods_cones.jpg

Rods and Cones



Rods: Sensitive to light energy

For low-light vision

"Scotopic vision"

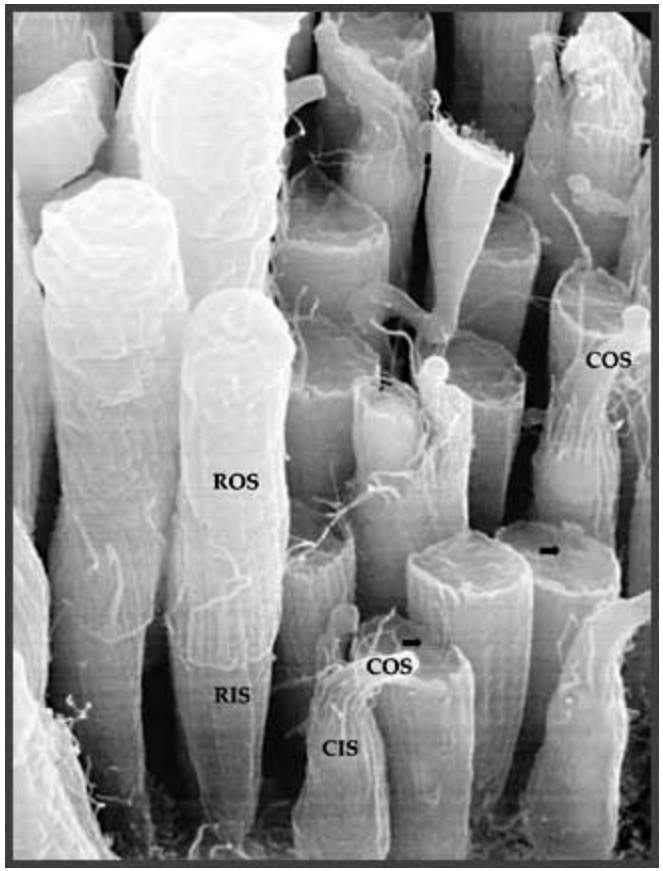
Cones: Sensitive to color

For high-light vision

"Photopic vision"

http://hamwaves.com/antennas/diel-rod/rods_cones.jpg

Rods and Cones



Rods: *Slow response*

Sensitive to light energy

Cones: *Fast response*

Sensitive to color

http://hamwaves.com/antennas/diel-rod/rods_cones.jpg

Practical Result

http://www.stanford.edu/~justso1/assets/smooth_local_histograms.pdf

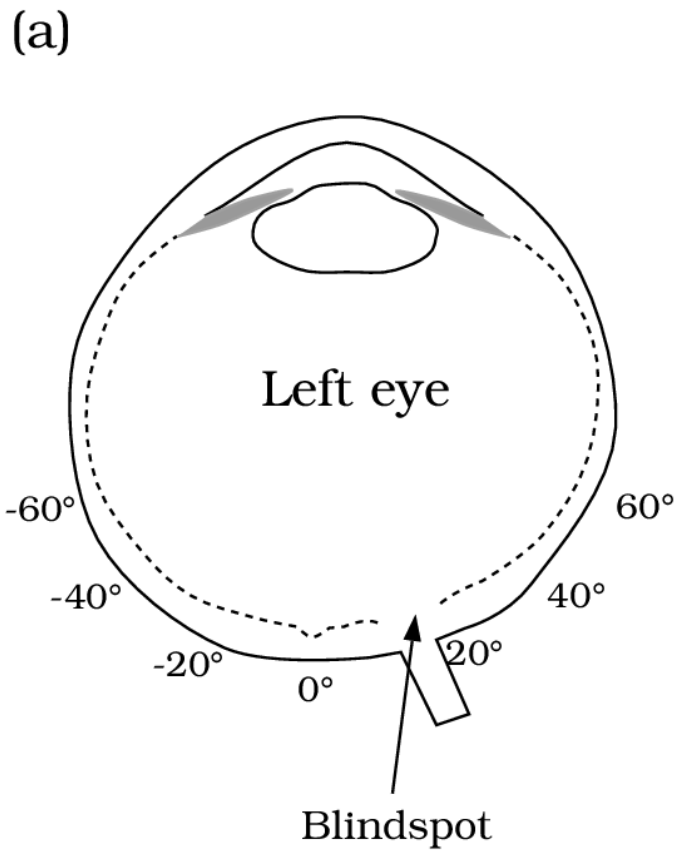
Can apply image operators only to brightness channel!

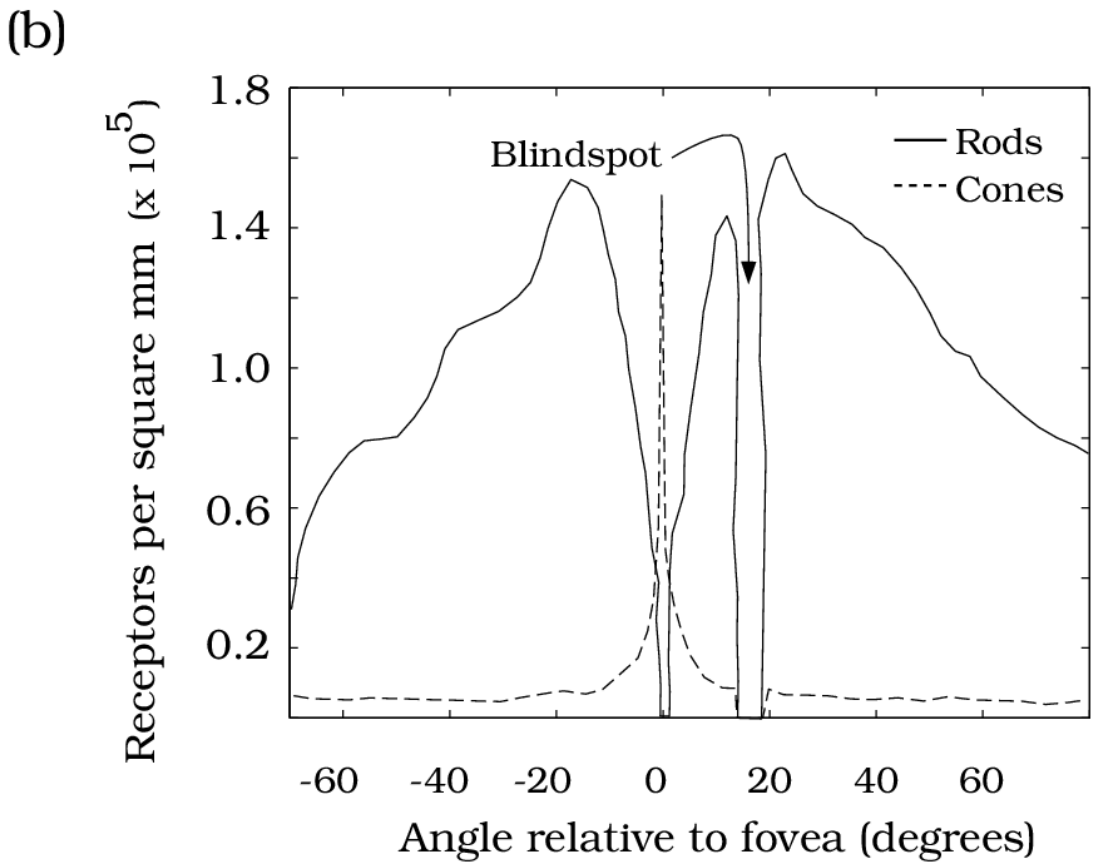
Practical Result

http://www.stanford.edu/~justso1/assets/smooth_local_histograms.pdf

Can apply image operators only to brightness channel!

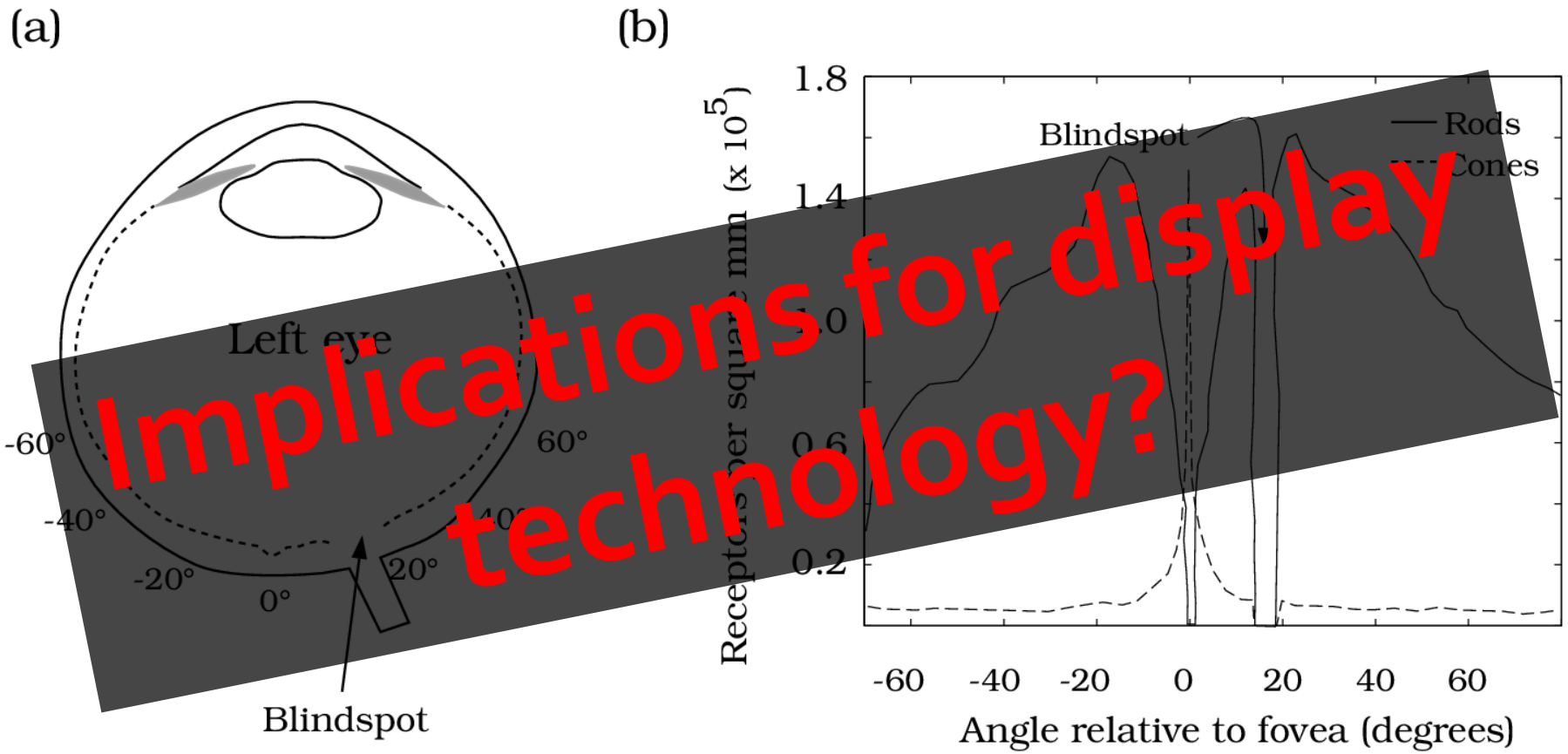
Distribution of Rods and Cones





https://www.stanford.edu/group/vista/cgi-bin/FOV/chapter-3-the-photoreceptor-mosaic/

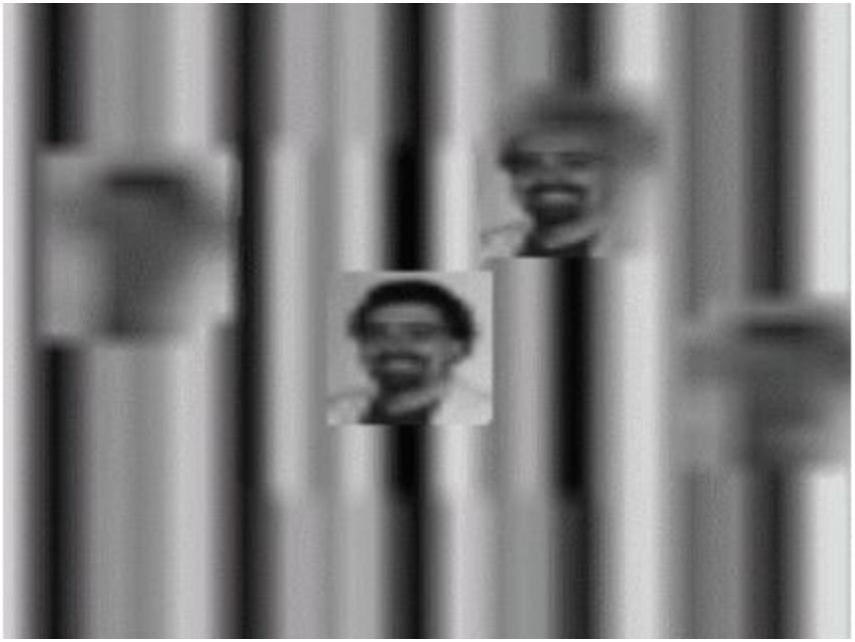
Distribution of Rods and Cones

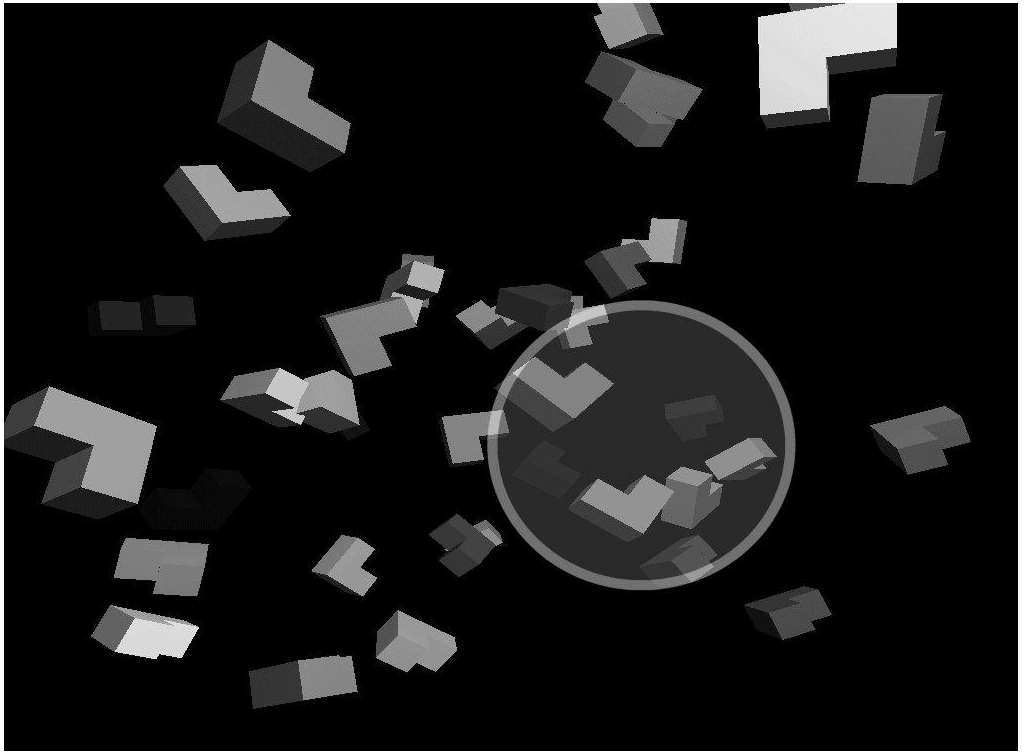


Implications for display technology?

https://www.stanford.edu/group/vista/cgi-bin/FOV/chapter-3-the-photoreceptor-mosaic/

Attentive Displays

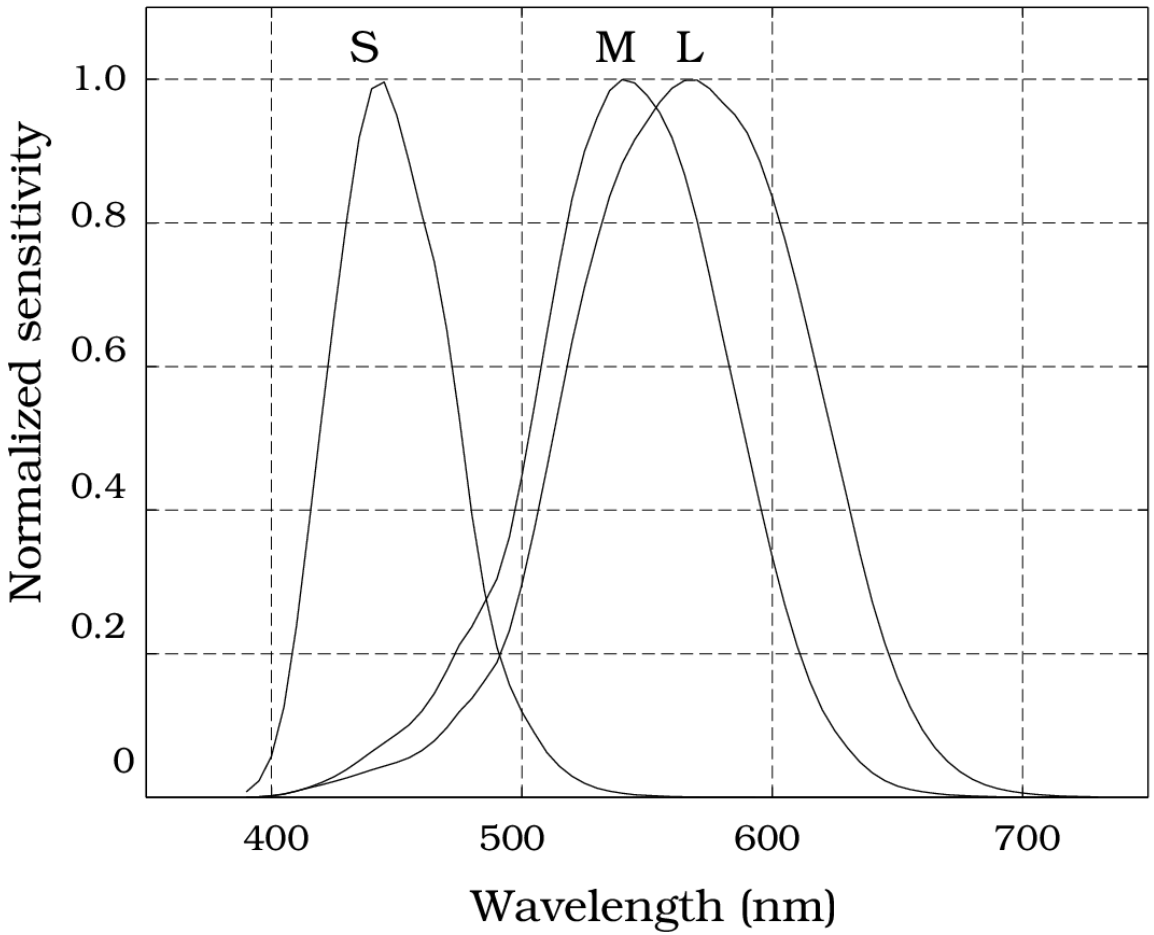




http://isg.cs.tcd.ie/oconork/papers/Perceptually%20Adaptive%20Graphics.pdf

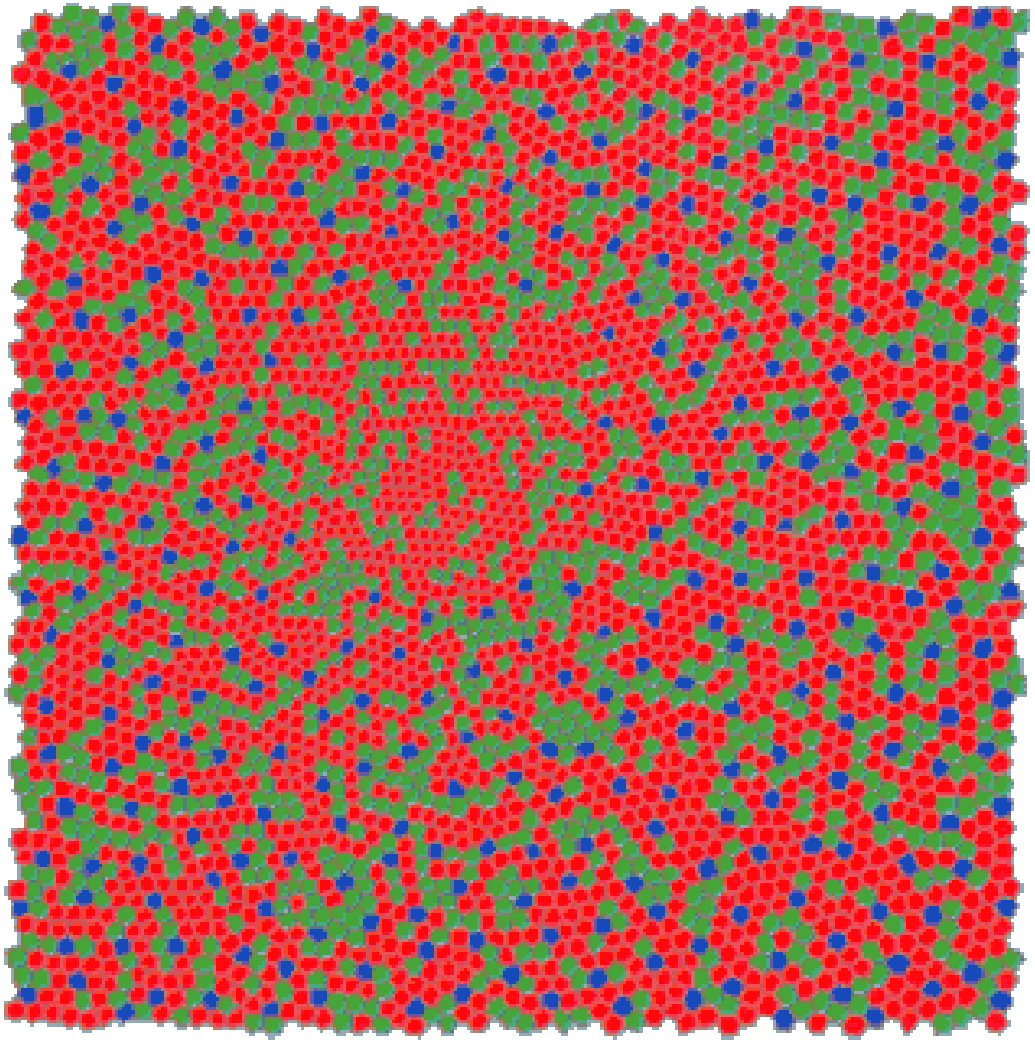
Focus computation where it helps

Types of Cones



http://www.stanford.edu/group/vista/cgi-bin/FOV/wp-content/uploads/2012/02/rec.spec_.sens_.png

Cone Mosaic



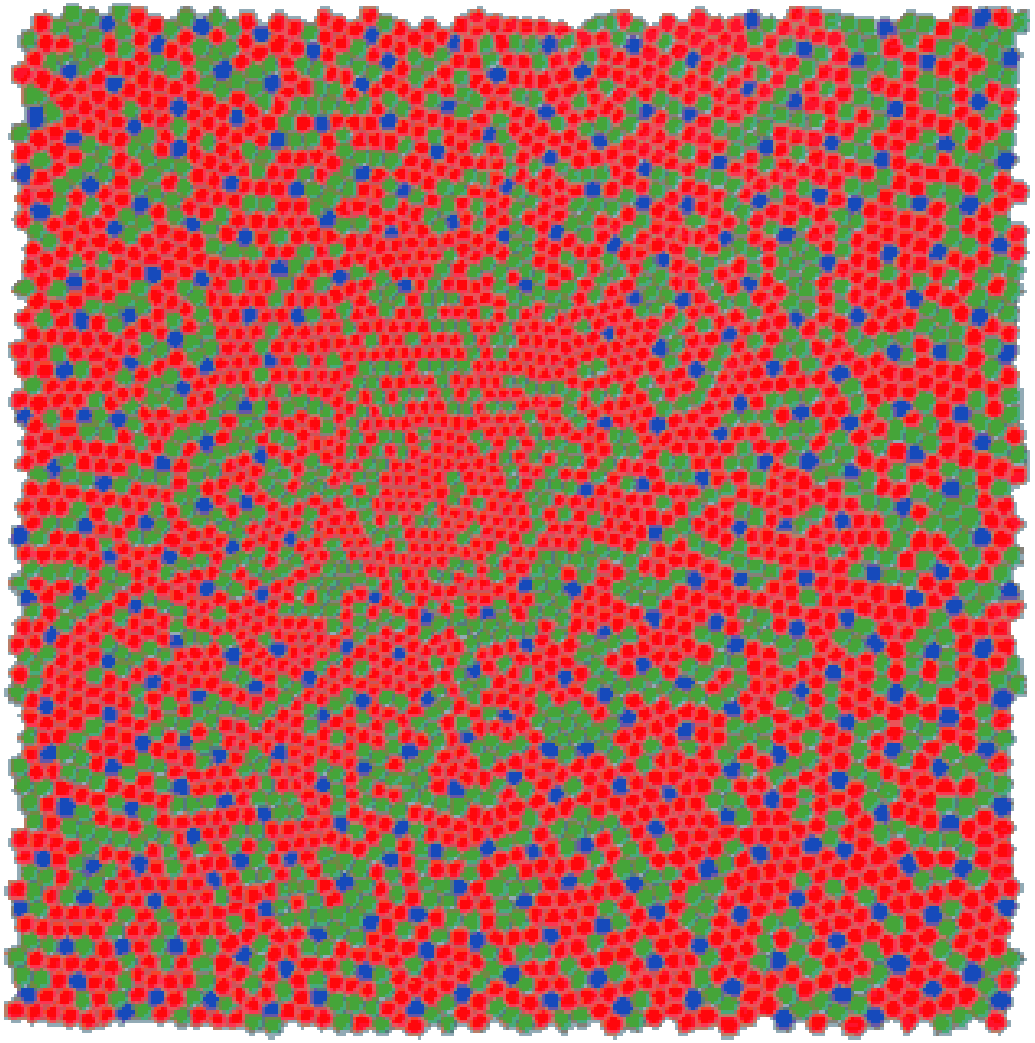
L:M:S

=

150:100:1

http://www.cis.rit.edu/people/faculty/montag/vandplite/pages/chap_9/ch9p1.html

Cone Mosaic



Fewer but more sensitive/amplified

L:M:S

=

150:100:1

http://www.cis.rit.edu/people/faculty/montag/vandplite/pages/chap_9/ch9p1.html

Night Driving

http://farm4.staticflickr.com/3077/2661951468_c7dcdaf2c0_z.jpg

Night Driving

http://farm4.staticflickr.com/3077/2661951468_c7dcdaf2c0_z.jpg

Night Driving

Why?

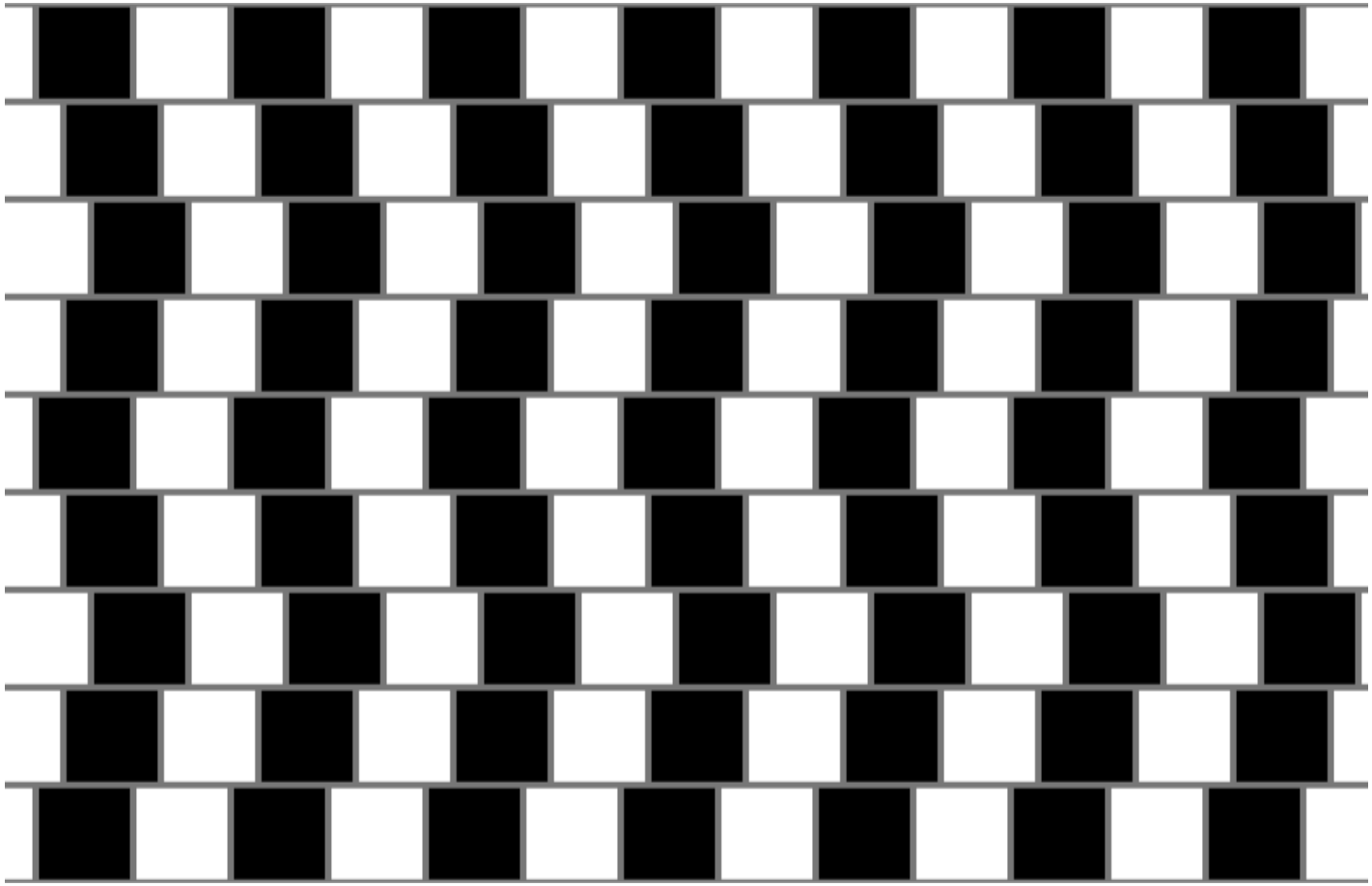
http://farm4.staticflickr.com/3077/2661951468_c7dcdaf2c0_z.jpg

Not a Trick, an Illusion

"Perception researchers have a long tradition of using visual illusions to demonstrate the different shortcuts and assumptions that the visual system uses."

- The Role of Perception in Computer Graphics, Bartz et al. 2008

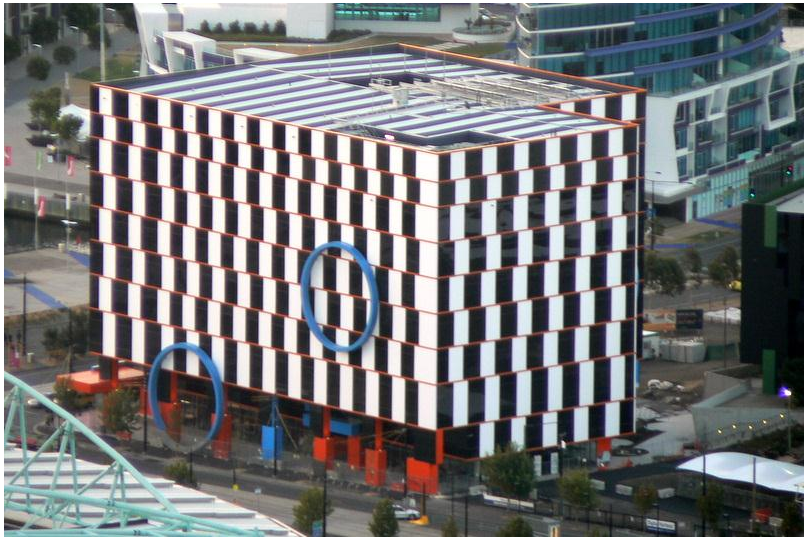
Not a Trick, an Illusion



http://upload.wikimedia.org/wikipedia/commons/d/d2/Caf%C3%A9_wall.svg

Café Wall Illusion – Parallel lines?

Not a Trick, an Illusion



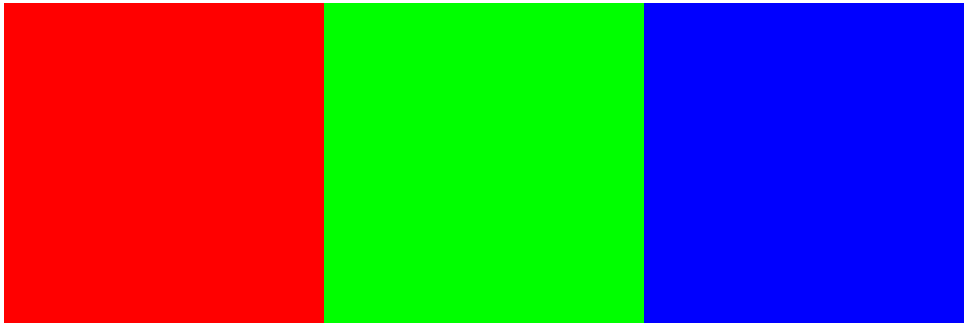
Irradiation:

Spread of light from dark to bright zones in retinal image

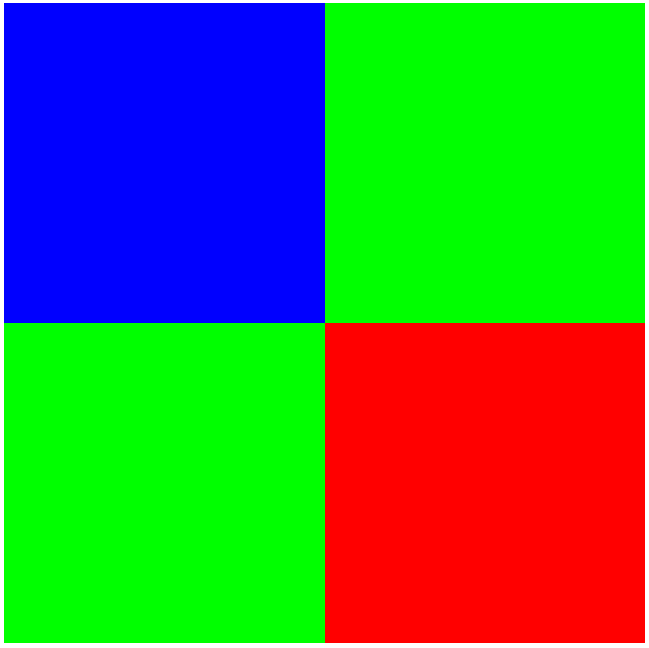
http://upload.wikimedia.org/wikipedia/en/0/03/Port1010DigitalHarbour.jpg

Café Wall Illusion – Parallel lines?

RGB

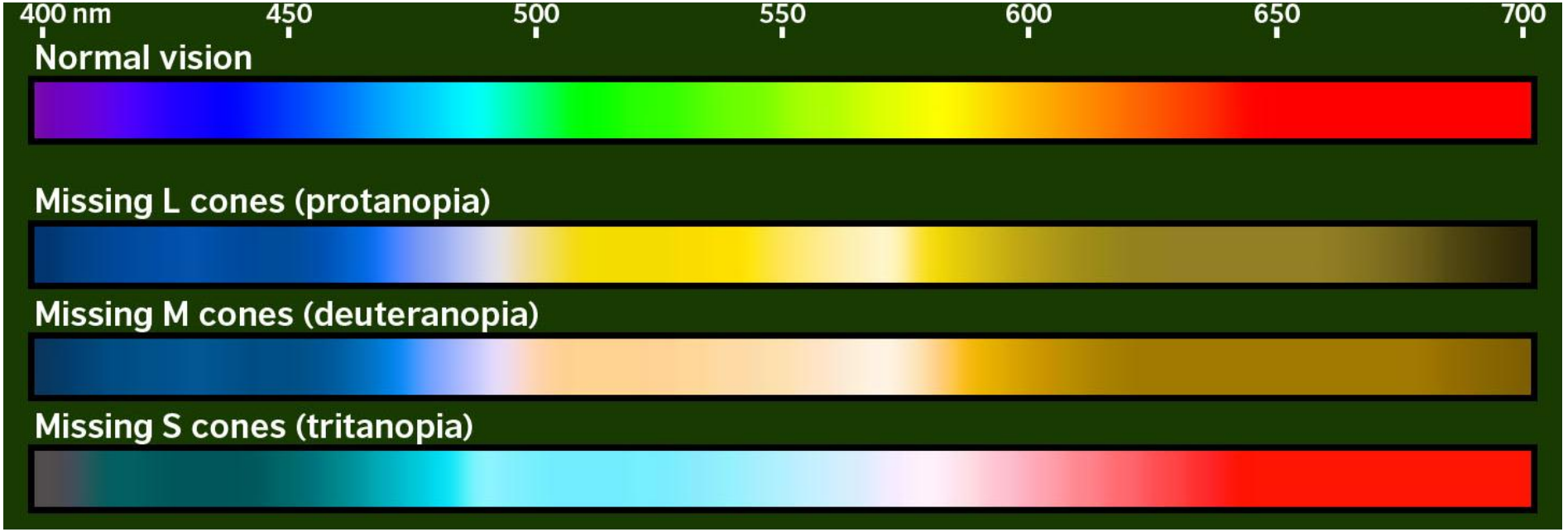


Typical pixel storage



Bayer pattern

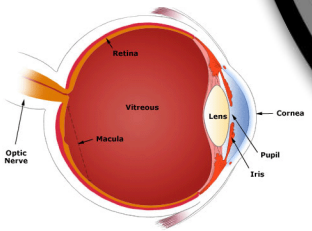
Color Blindness

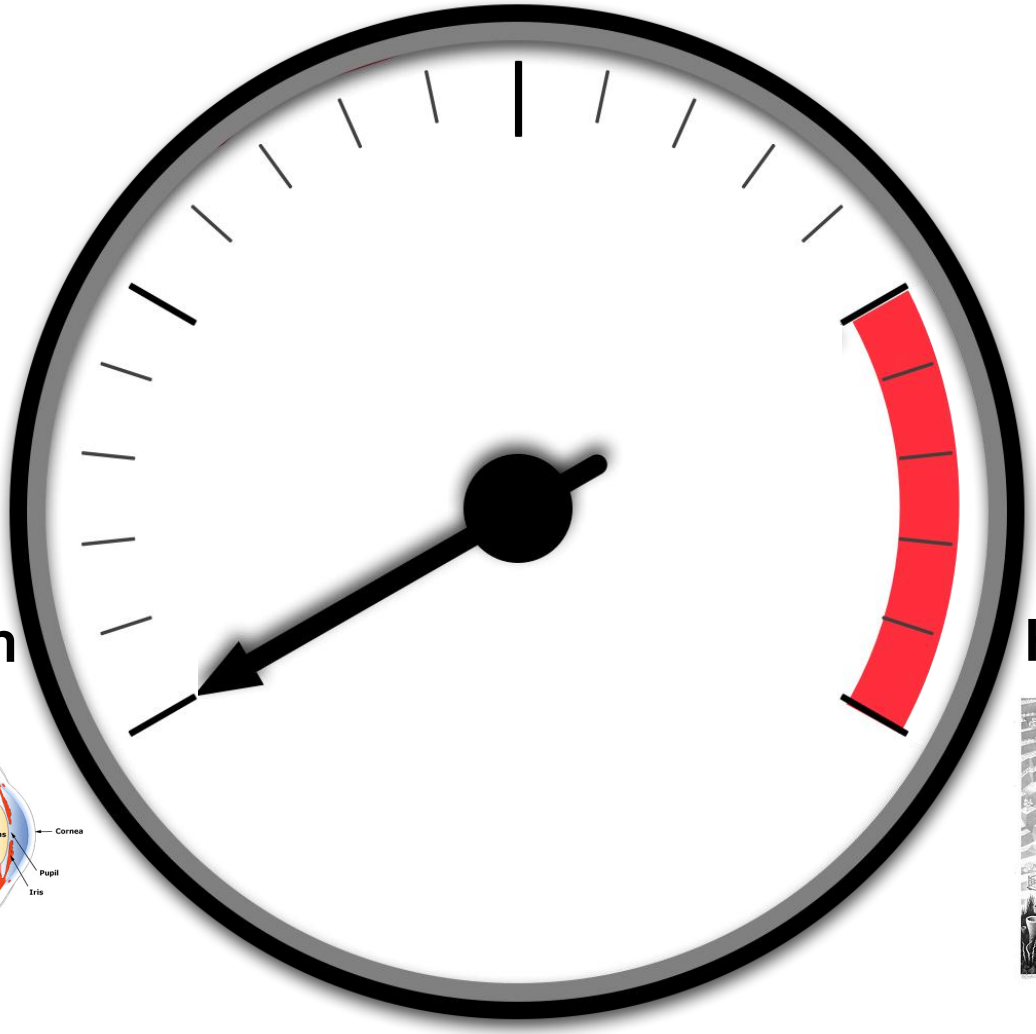


http://www.scifun.ed.ac.uk/pages/about_us/shows/cb/cb-spectra-bars.jpg

Theme for Today

Low-level vision

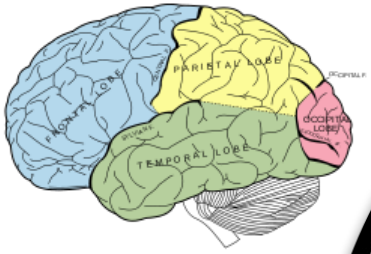


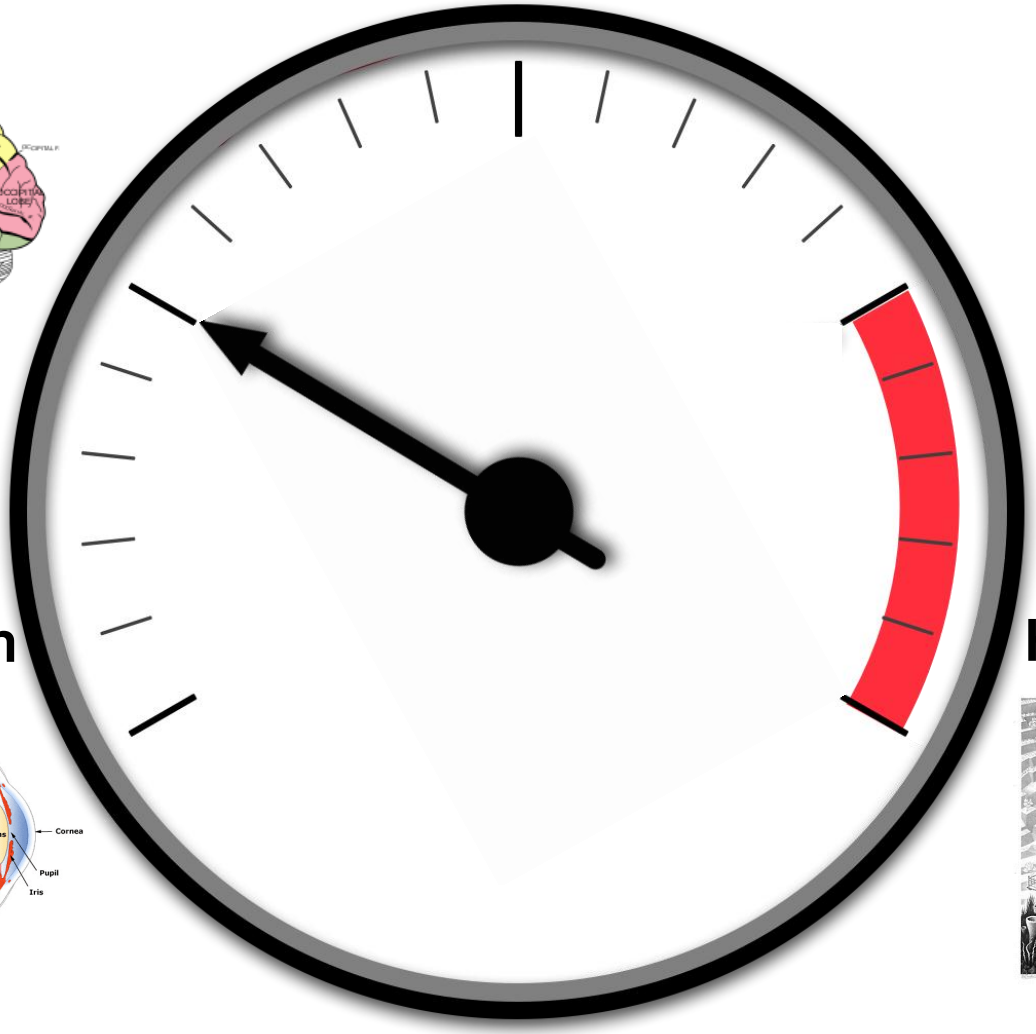


High-level vision

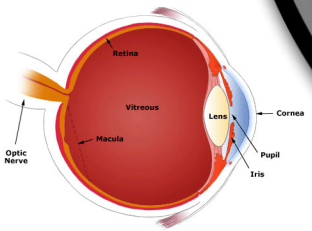
http://paco.to/wp-content/uploads/2007/02/speedometer.png

Theme for Today





Low-level vision



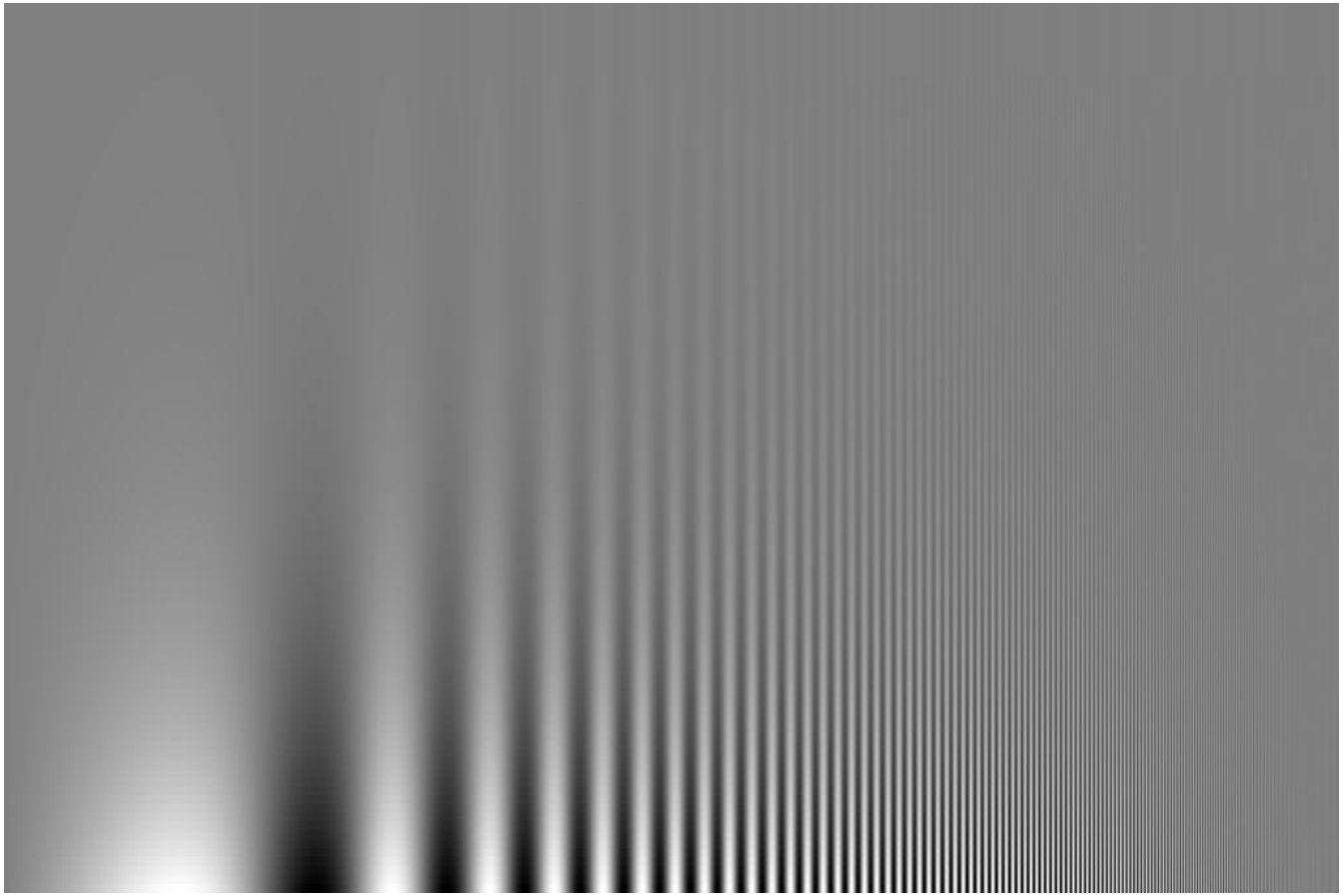
High-level vision

http://paco.to/wp-content/uploads/2007/02/speedometer.png

Visual Sensitivity

Vision system tuned to detect patterns rather than magnitude of light.

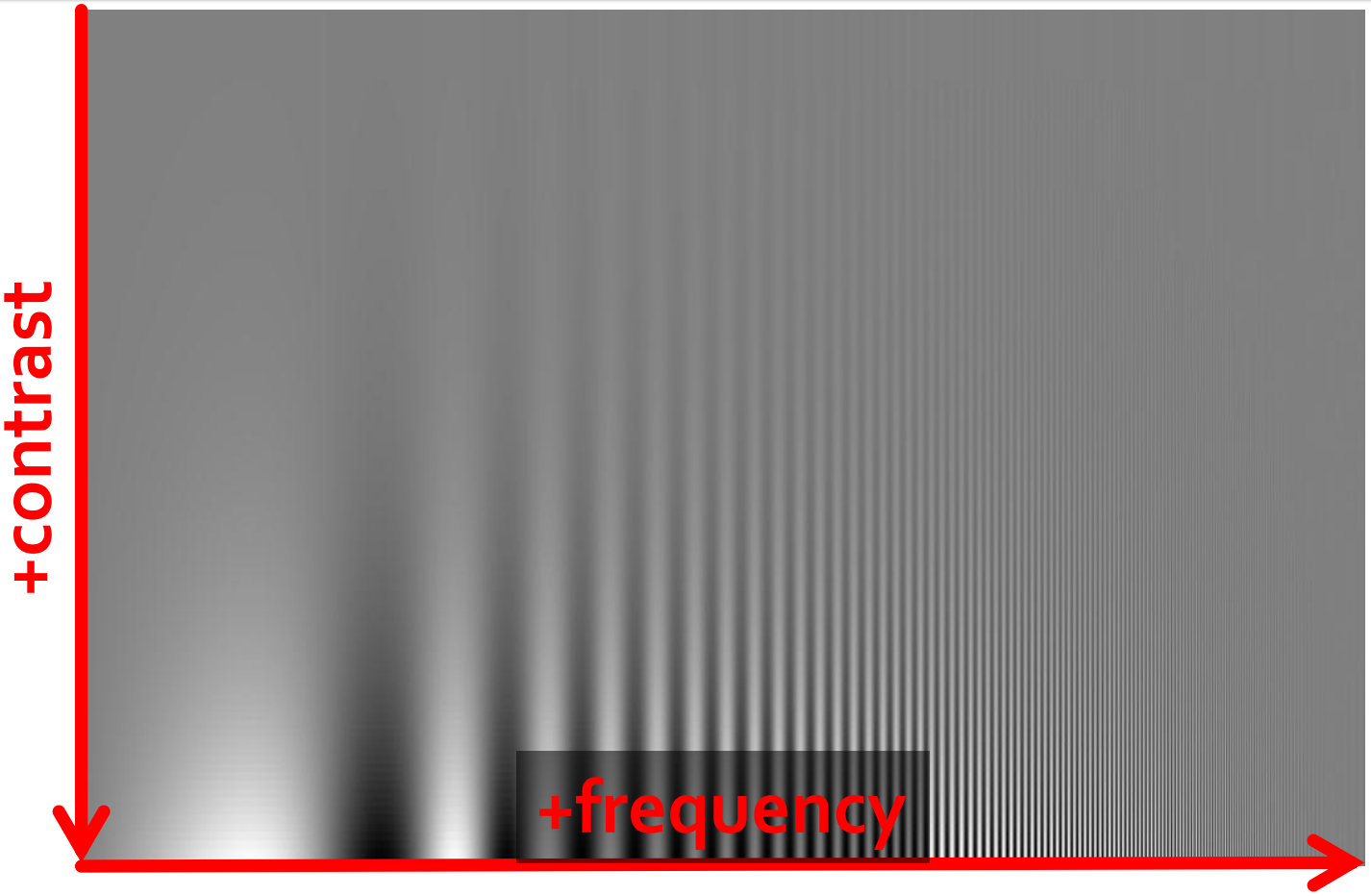
Visual Acuity



http://stonerosephotos.com/blog/2012/04/all-that-resolution/

Ability to detect fine patterns

Visual Acuity



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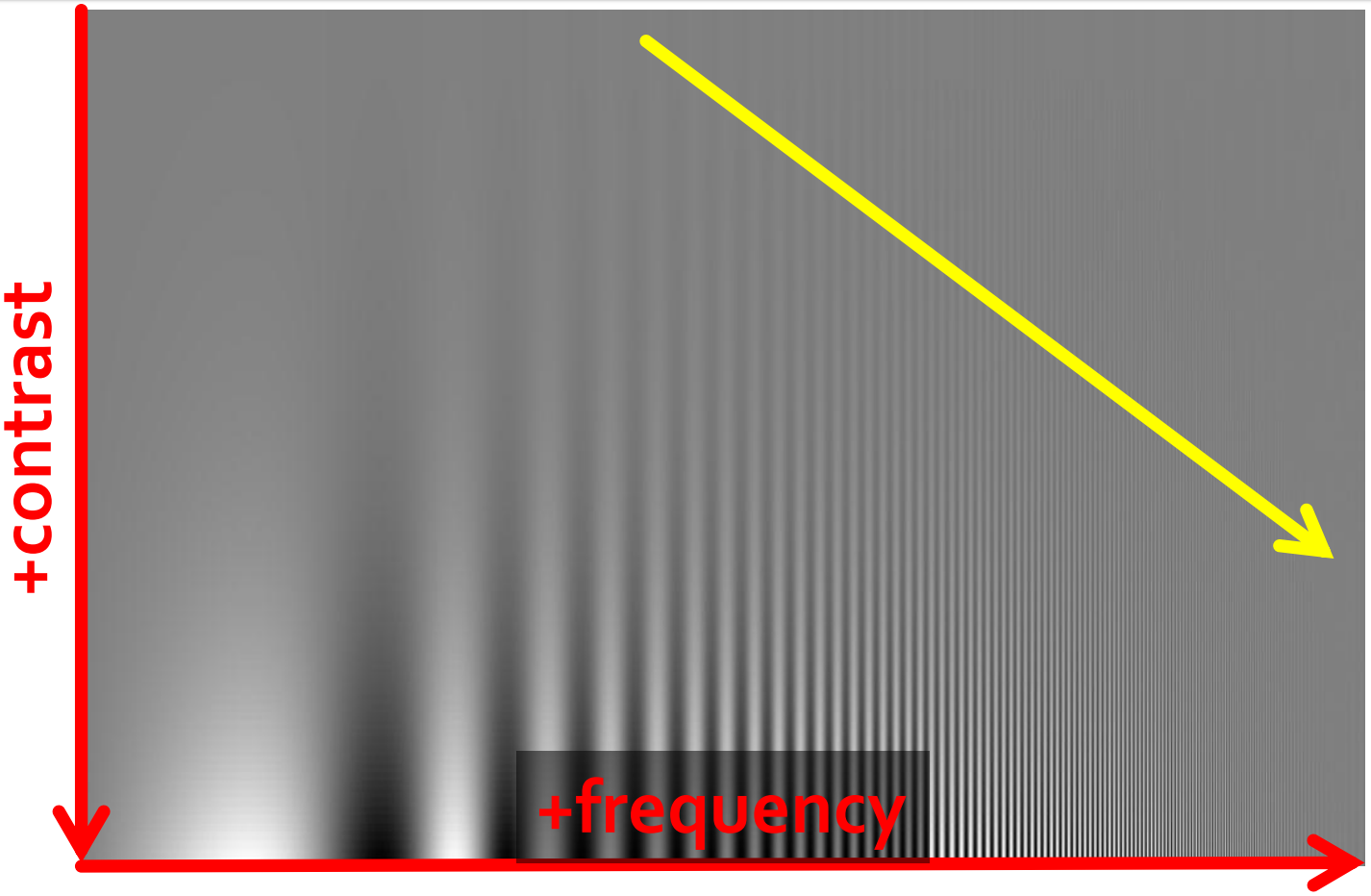

Ability to detect fine patterns

Context Dependence

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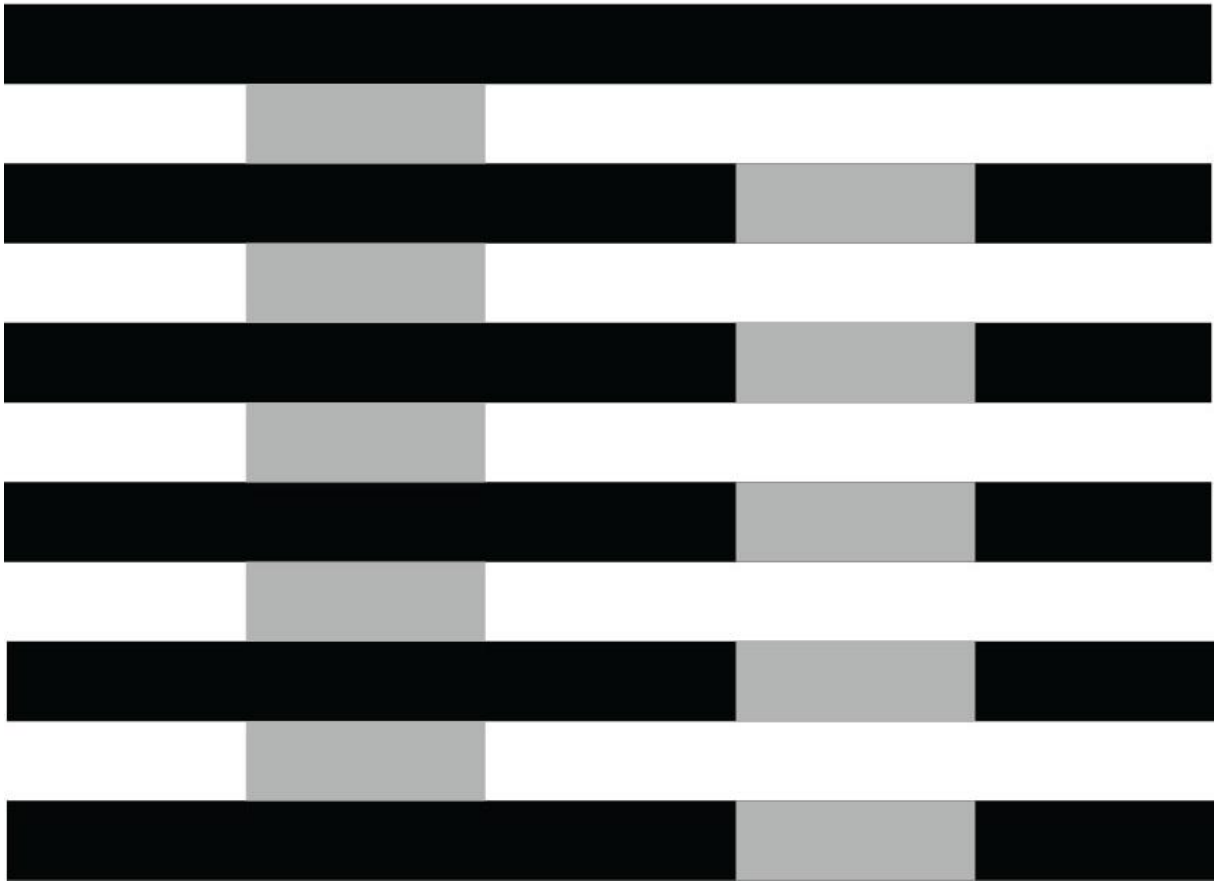
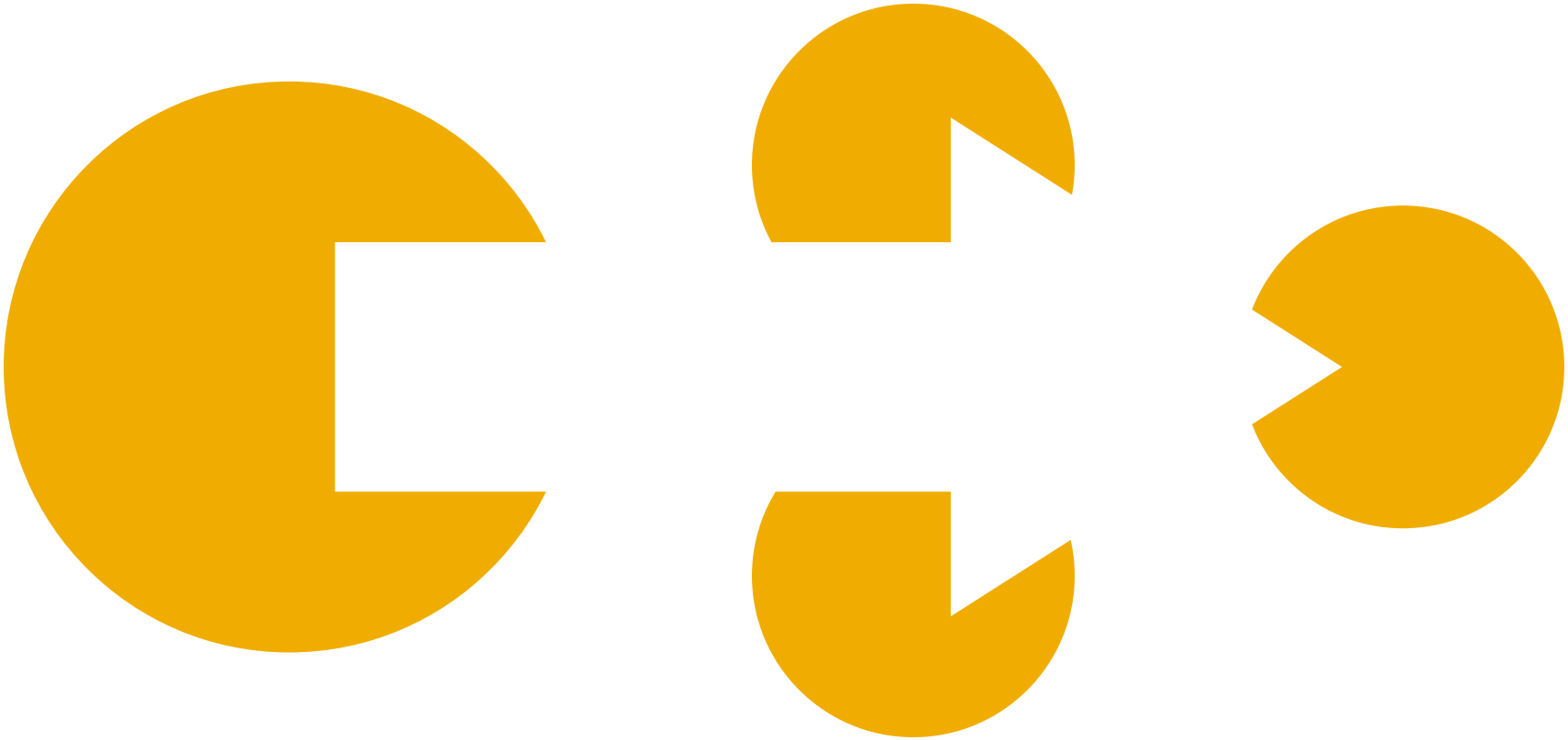


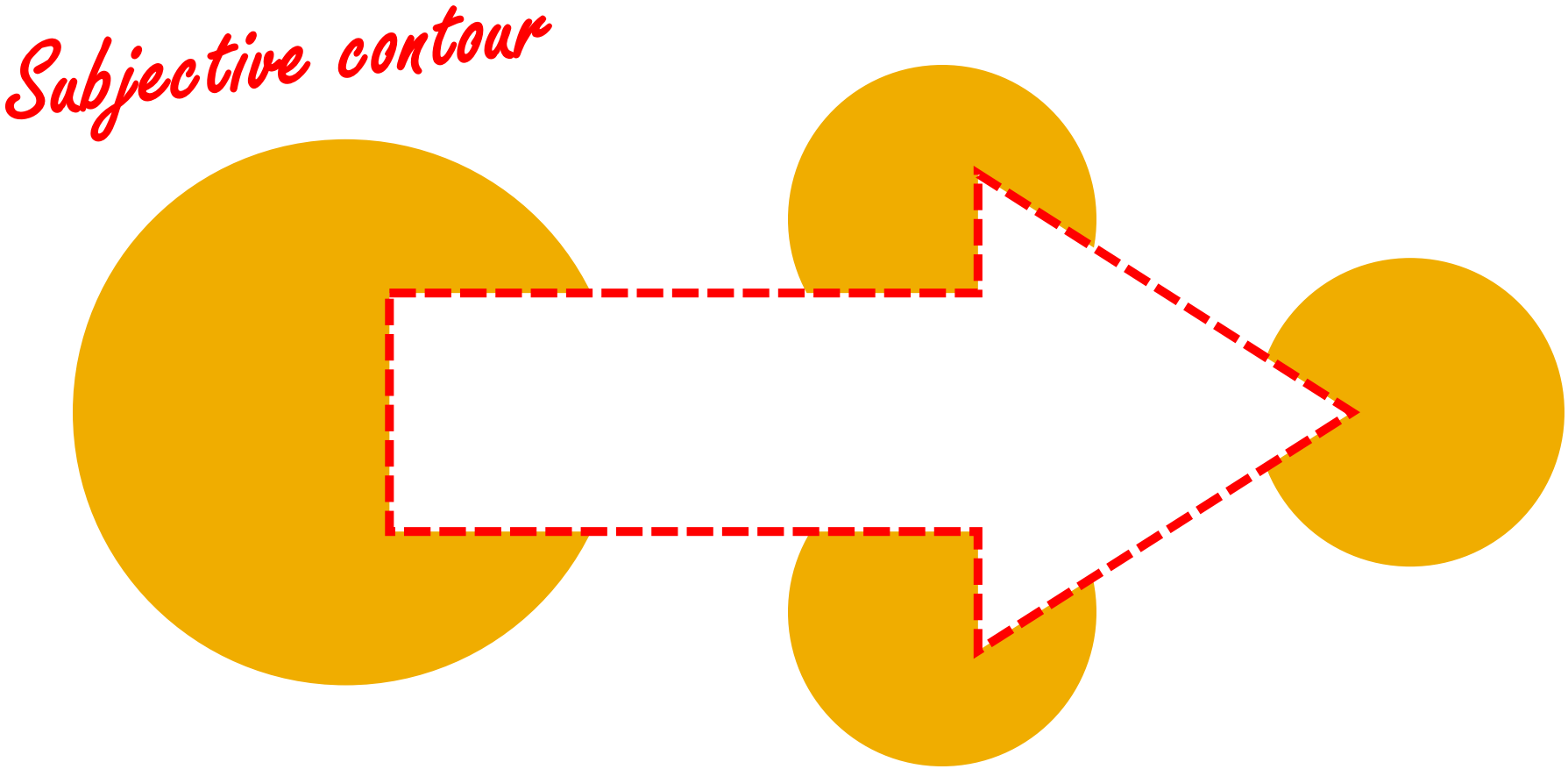
http://upload.wikimedia.org/wikipedia/commons/d/d2/Whites_illusion.jpg

Munker-White illusion

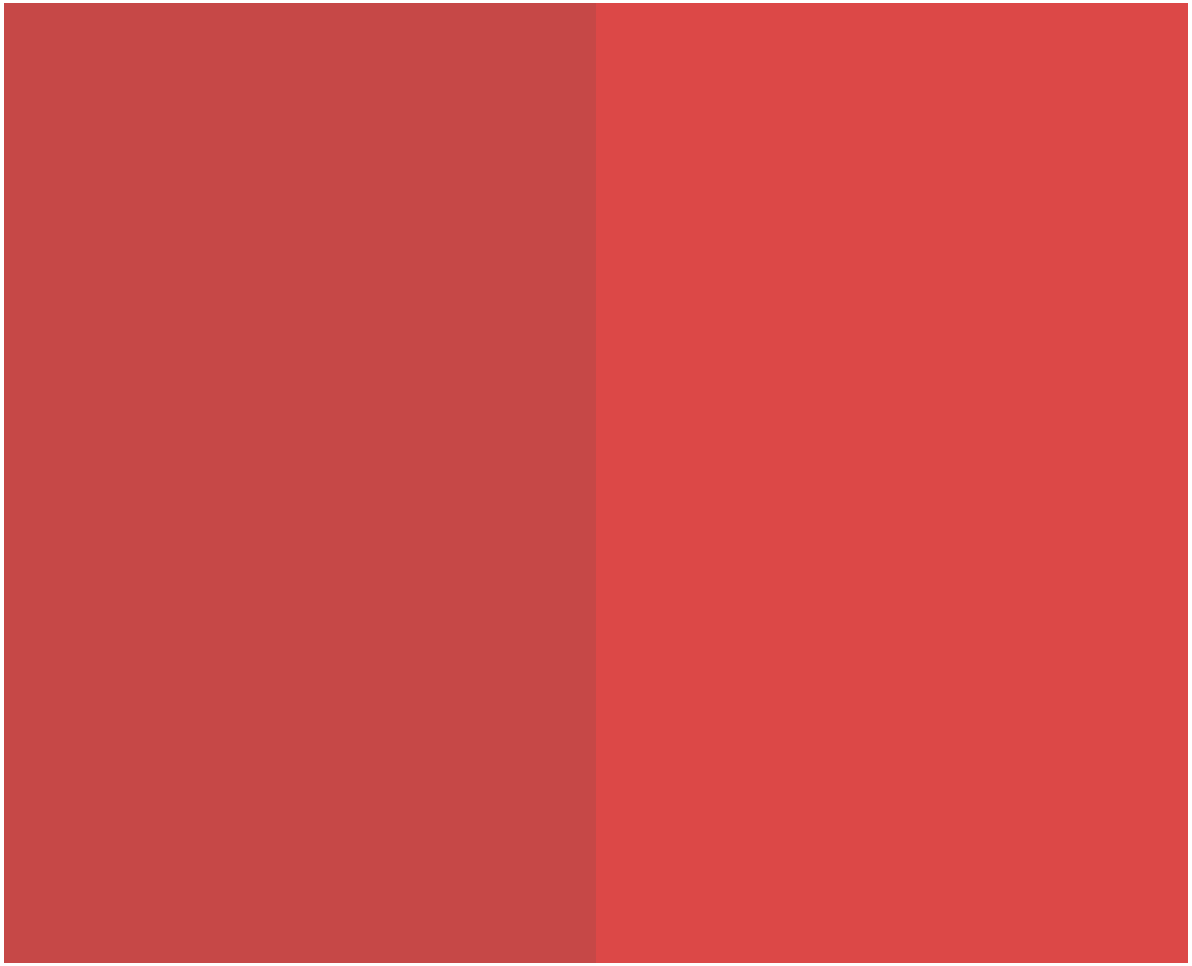
Conclusion: Edges Are Important



Conclusion: Edges Are Important

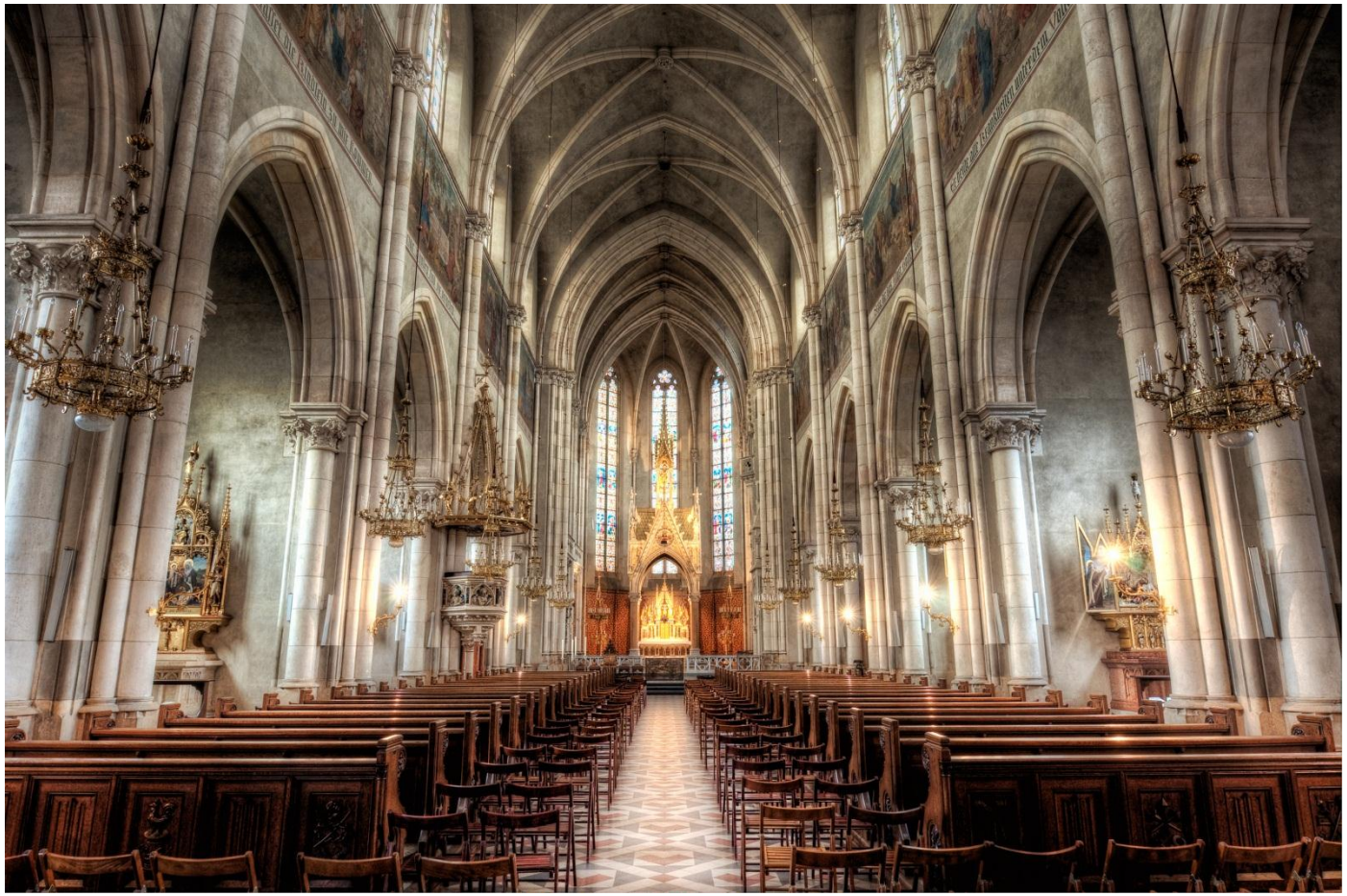


Conclusion: Edges Are Important



Conclusion: Edges Are Important

Dynamic Range

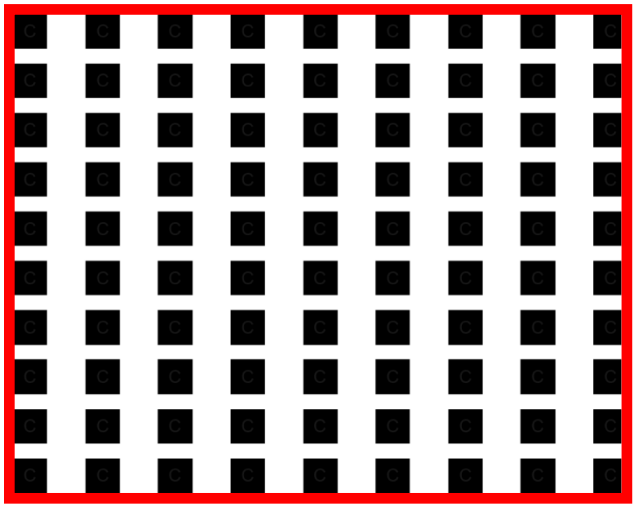


http://www.bartelme.at/material/hdr/hdr5.jpg

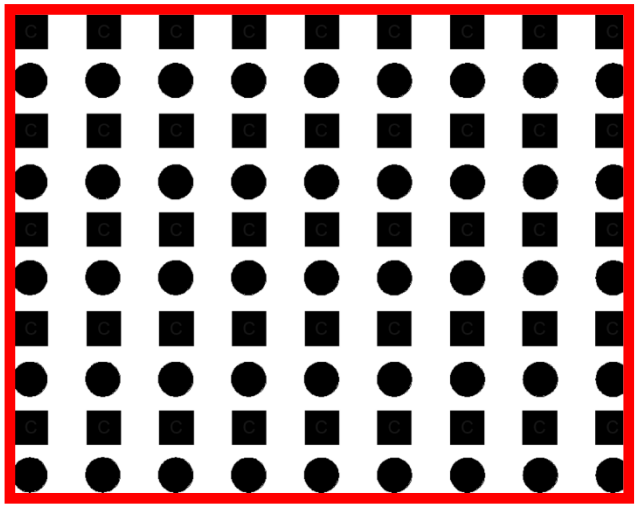
Six orders of magnitude, but not at once

Organizational Processes

Emergent patterns



Organization by proximity

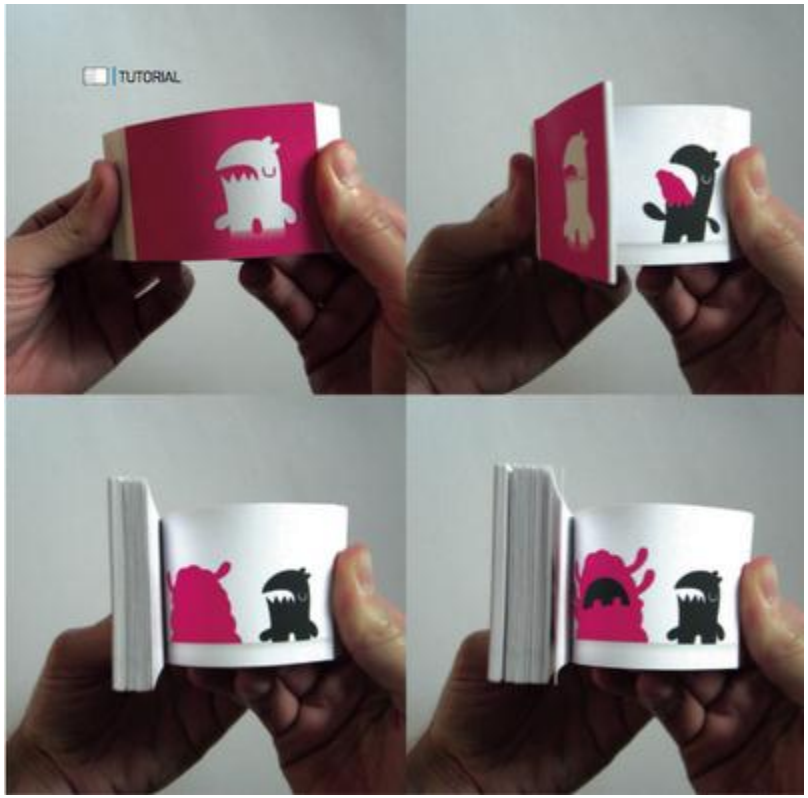


Organization by similarity

http://www.gris.uni-tuebingen.de/people/staff/bartz/Publications/paper/paper/bartz2008-egstar.pdf

Detecting/Processing Motion

Visual sensors must communicate!



Discontinuous motion with same average velocity as implied **continuous motion**.

http://darlingdarleen.blogspot.com/2008_01_01_archive.html

Minimum Motion Constraints

- Update rate must be at least 10 Hz
- Flicker fusion occurs above 60-80 Hz

Minimum Motion Constraints

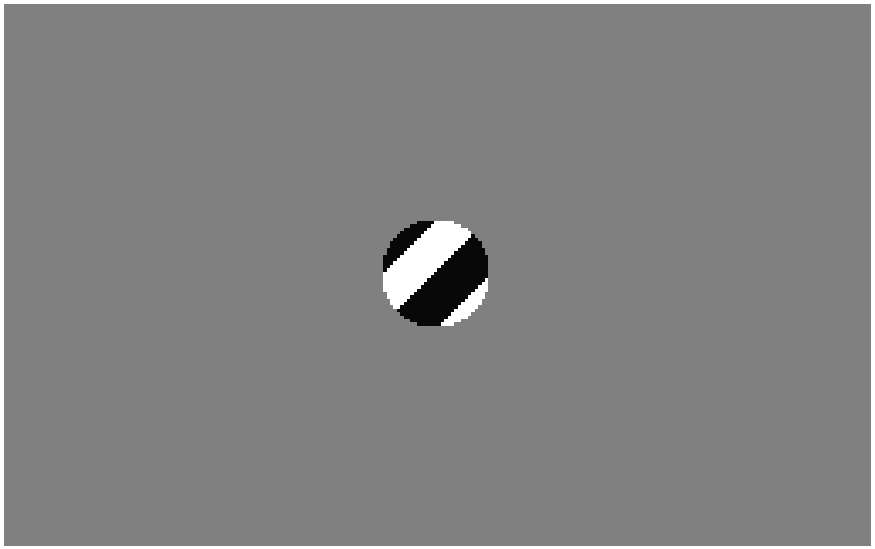
- Update rate must be at least 10 Hz

"Frame update rate"

- Flicker fusion occurs above 60-80 Hz

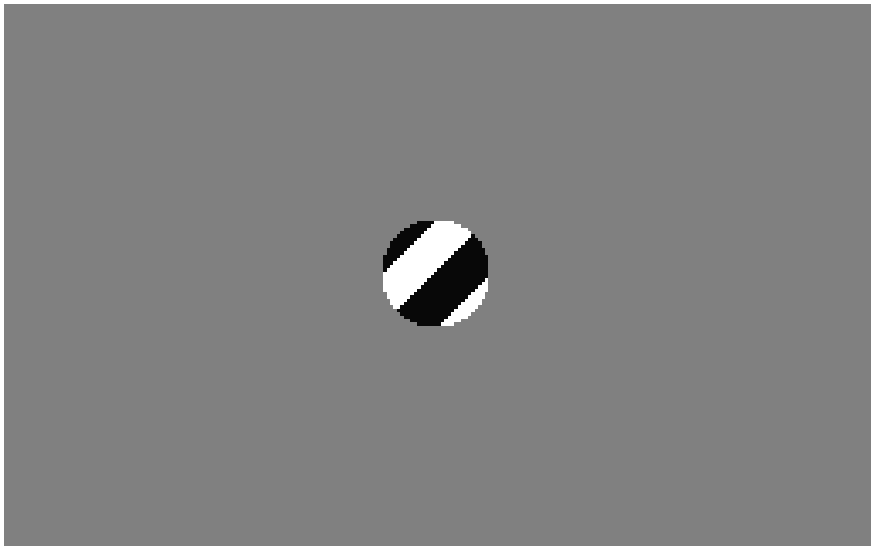
"Refresh rate"

Aperture Problem



http://upload.wikimedia.org/wikipedia/commons/f/fo/Aperture_problem_animated.gif
http://2.bp.blogspot.com/-6LnK6MaXArg/TiLPPgmmyMI/AAAAAAAABdU/b87U2CDESfo/s1600/barber-shop-pole.jpg

Aperture Problem



Flat texture gives no motion cues!

http://upload.wikimedia.org/wikipedia/commons/f/fo/Aperture_problem_animated.gif
http://2.bp.blogspot.com/-6LnK6MaXArg/TiLPPgmmyMI/AAAAAAAABdU/b87U2CDESfo/s1600/barber-shop-pole.jpg

Depth Cue Categories

- **Ocularmotor**: Position and focus of eyes
- **Disparity**: Use of two eyes
- **Motion**: Movement of observer or objects

Depth Cue Roles

- **Absolute**: standard that is not part of the sensed information itself
- **Relative**: relate perceived geometric properties to one another
- **Ordinal**: Type of relative measure where sign but not magnitude of relation is represented

Depth Cue Roles

- **Absolute**: standard that is not part of the sensed information itself
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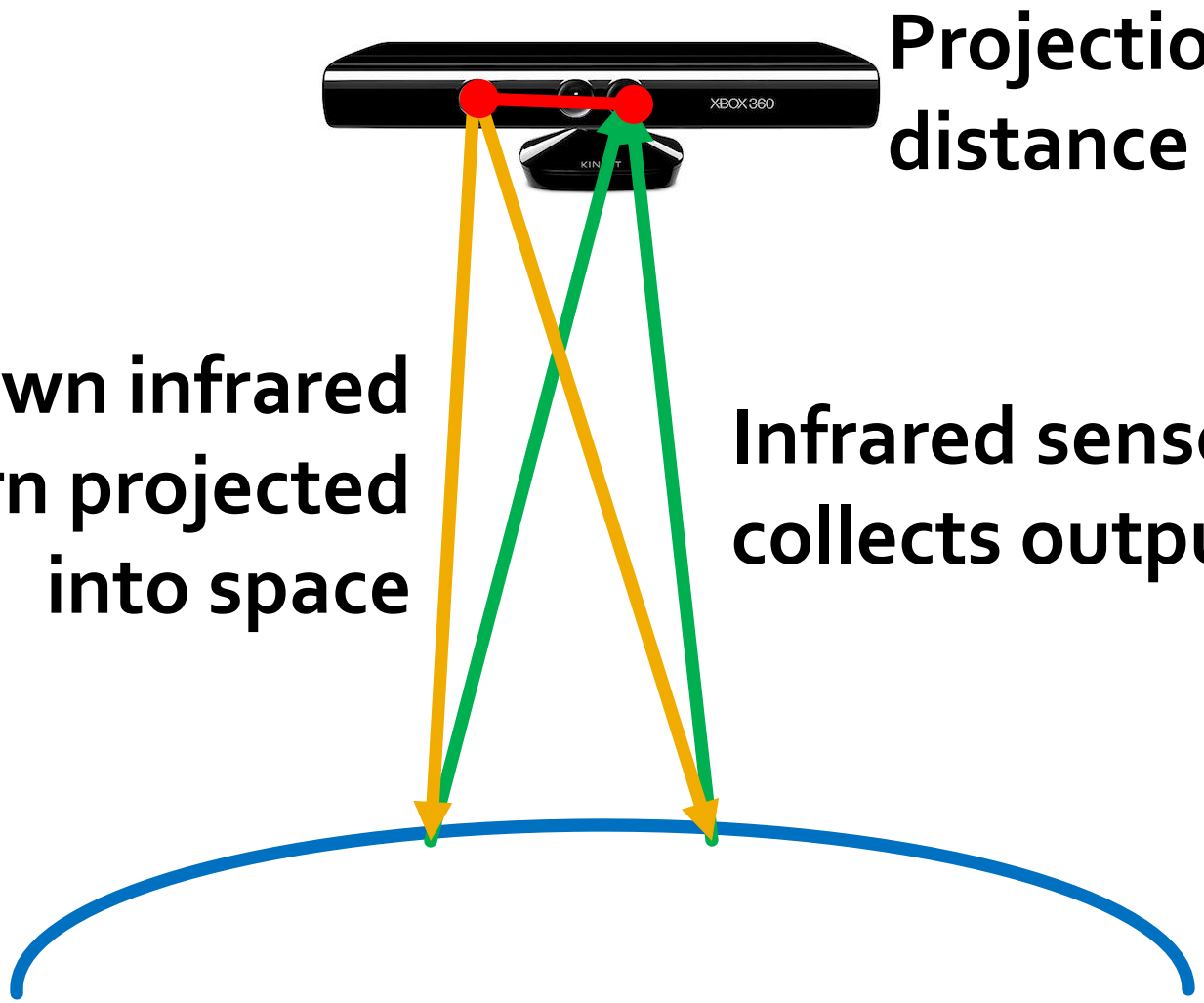
Be sure you can list examples of these…

Inspiration for Computer Vision

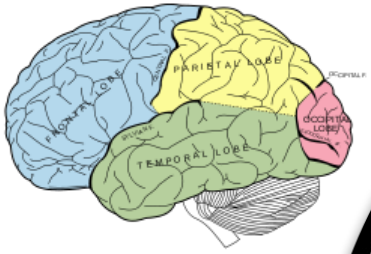
Microsoft Kinect

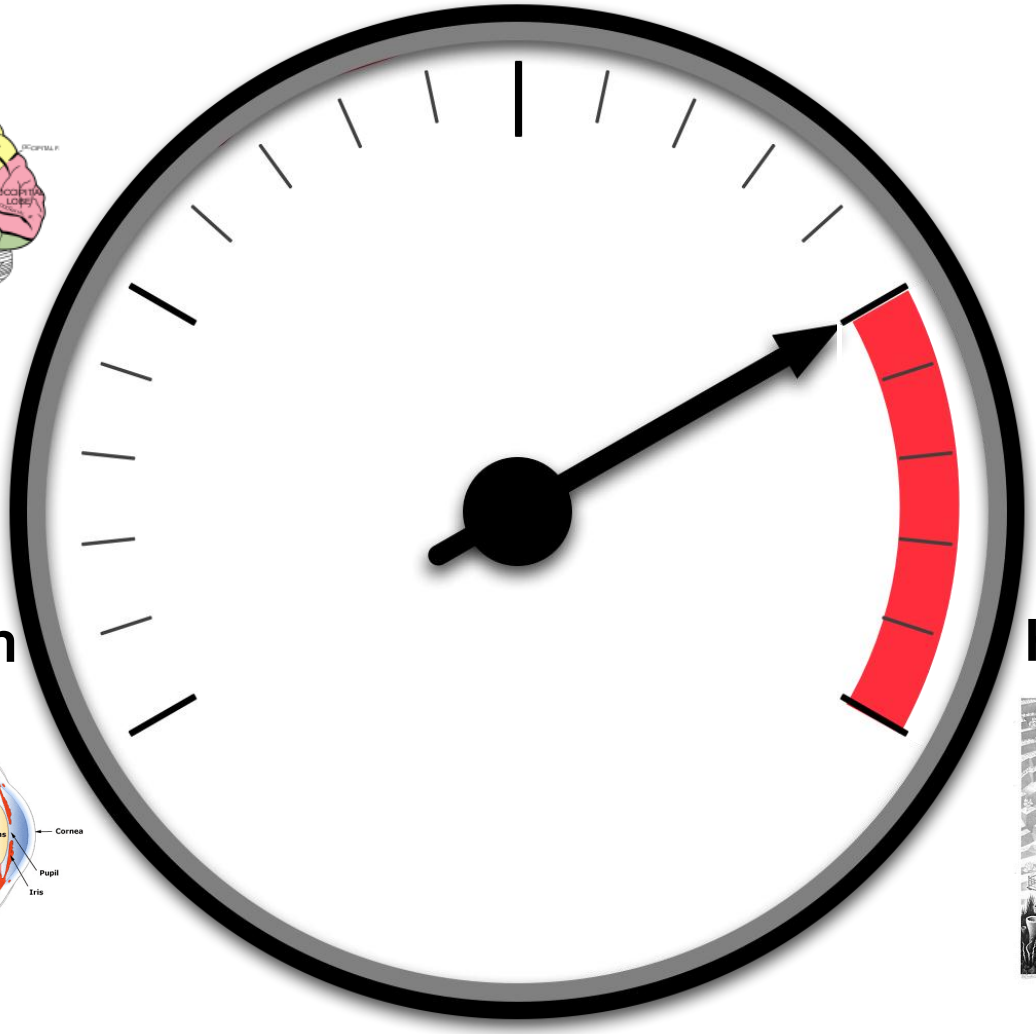
http://bbzippo.files.wordpress.com/2010/11/dsc00014s_thumb.jpg?w=700&h=528

Inspiration for Computer Vision

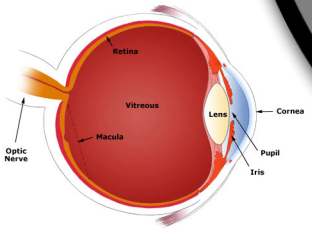


Theme for Today





Low-level vision



High-level vision

http://paco.to/wp-content/uploads/2007/02/speedometer.png

Interesting Question

OK with this…

http://en.wikipedia.org/wiki/Ted_%28film%29
http://upload.wikimedia.org/wikipedia/commons/a/aa/Repliee_Q2.jpg

Interesting Question

OK with this…

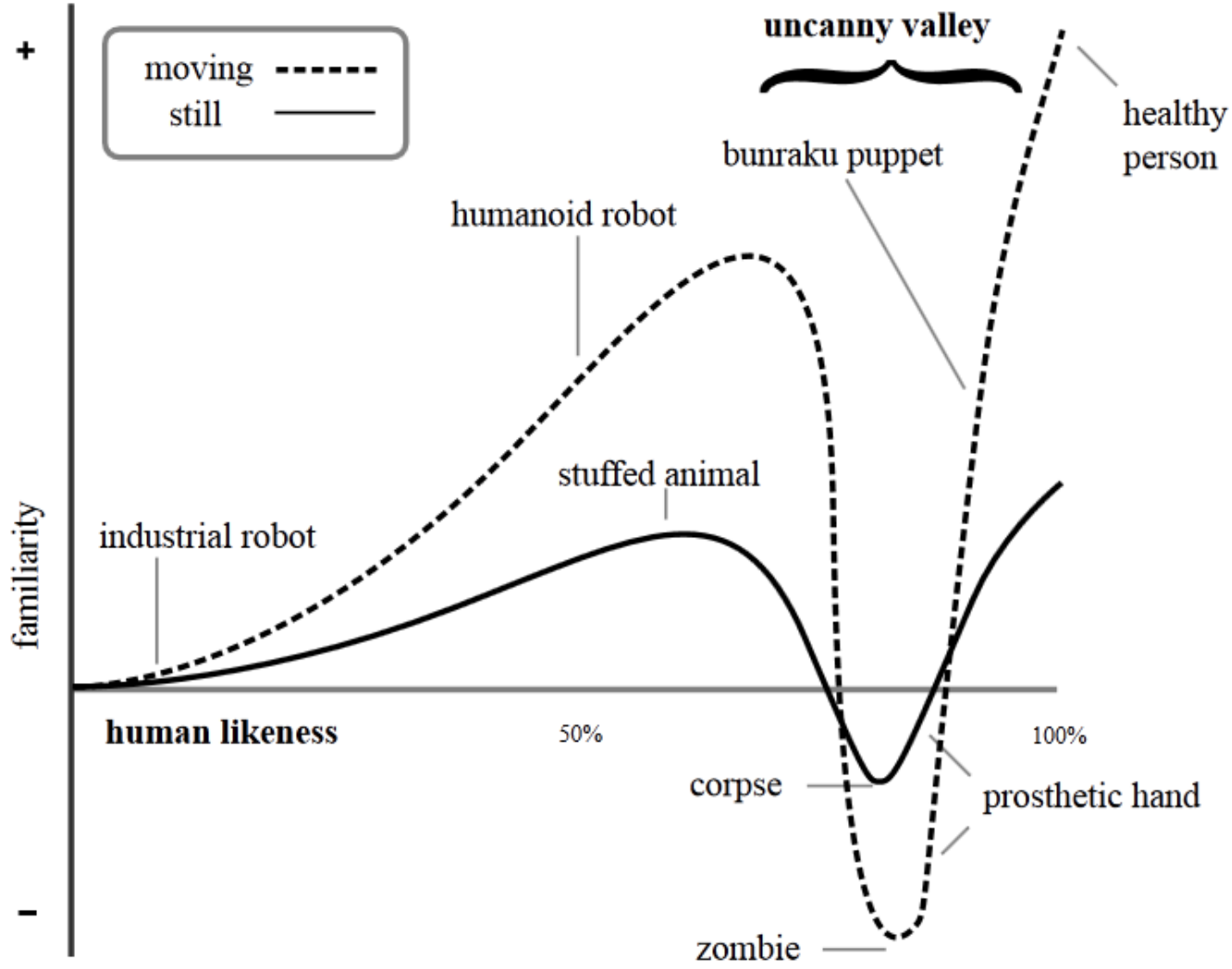
but not this?

http://en.wikipedia.org/wiki/Ted_%28film%29
http://upload.wikimedia.org/wikipedia/commons/a/aa/Repliee_Q2.jpg

Another Example

http://www.youtube.com/watch?v=oZgkInGIWFQ

Uncanny Valley



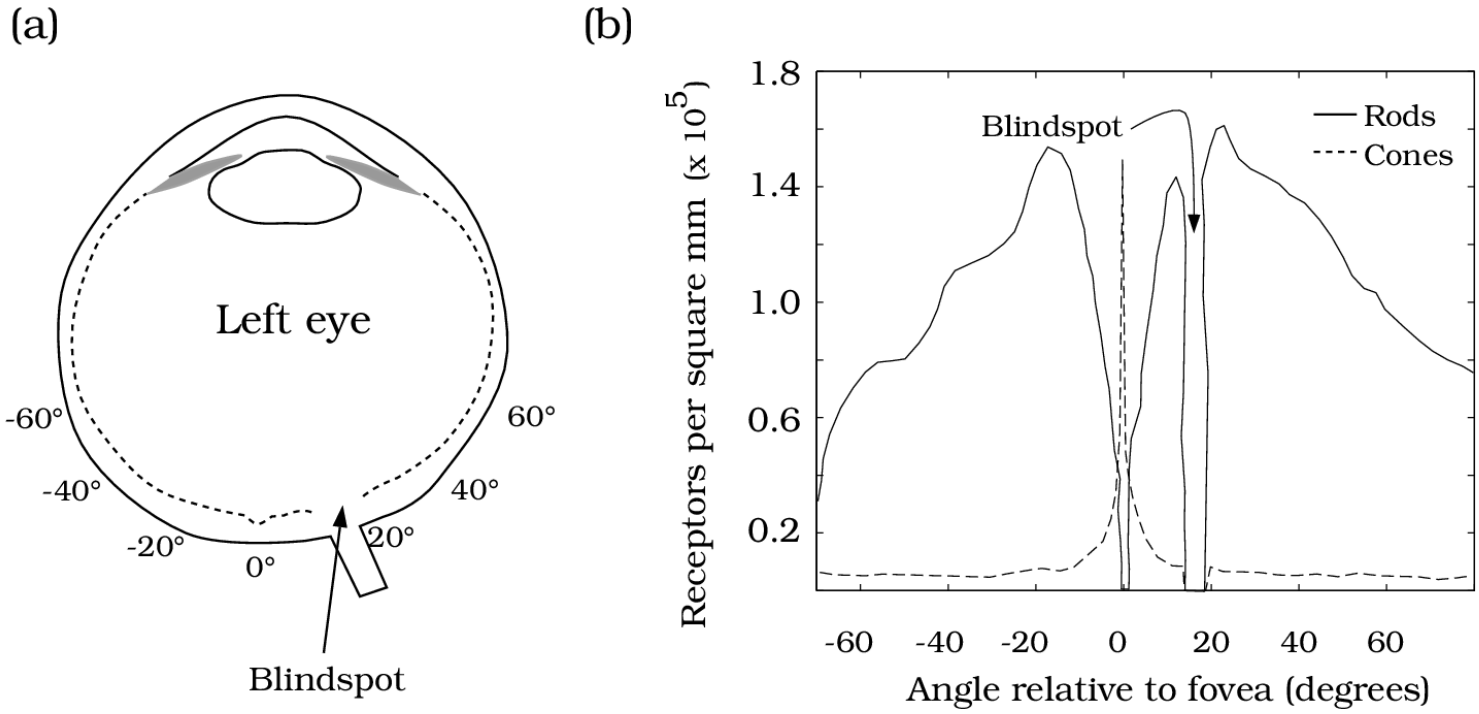
http://en.wikipedia.org/wiki/File:Mori_Uncanny_Valley.svg

Potential Explanations

- Mate selection
- Mortality salience
- Pathogen avoidance
- Violation of norms
- Religion
- …

http://en.wikipedia.org/wiki/Uncanny_valley

Why Bother?



Do extra computation where it matters

Why Bother?

http://gotgame.com/wp-content/uploads/2012/04/mind-video-games.jpg

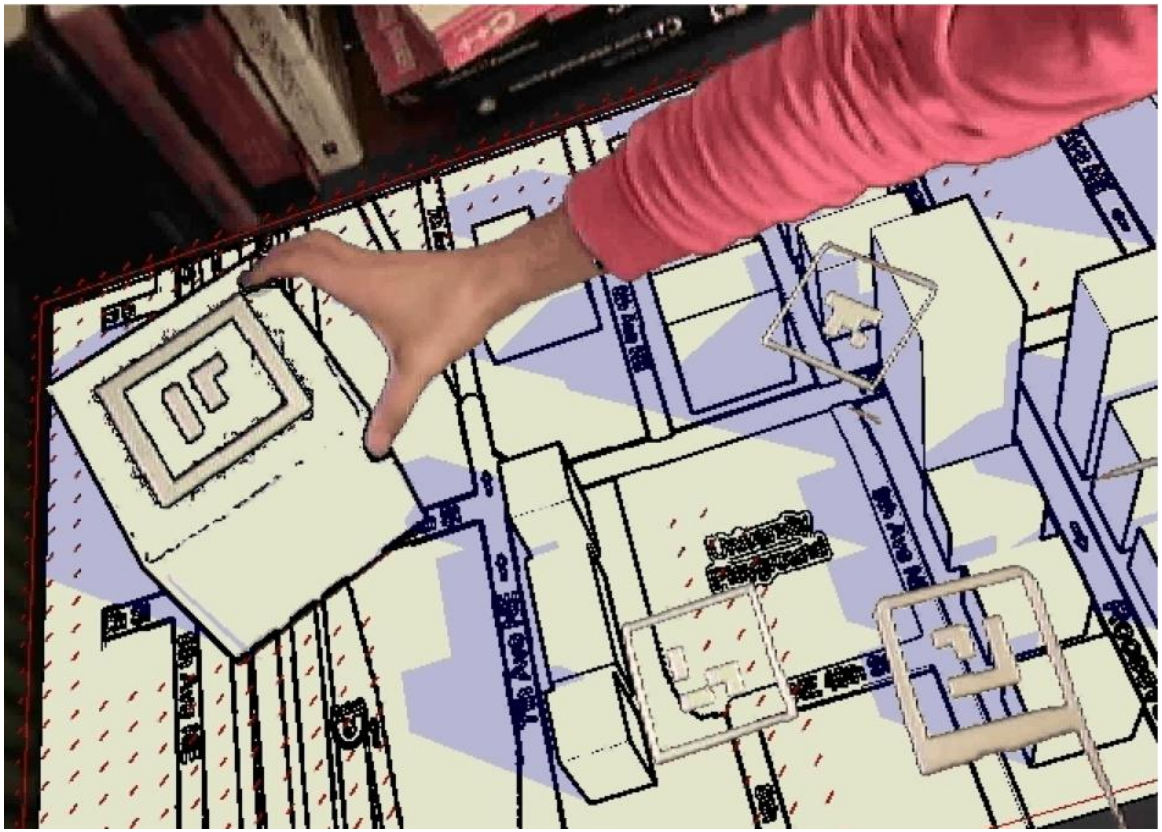
"Real-time" vs. "Interactive"

Why Bother?

http://www.gris.uni-tuebingen.de/people/staff/bartz/Publications/paper/paper/bartz2008-egstar.pdf

Design usable interfaces

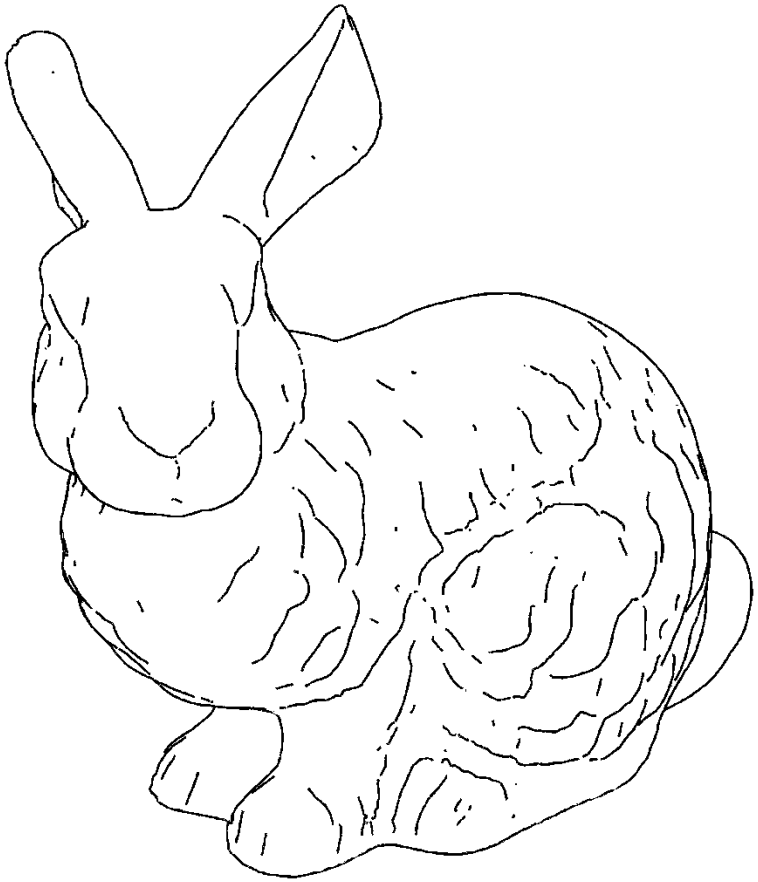
Why Bother?



http://www.gris.uni-tuebingen.de/people/staff/bartz/Publications/paper/paper/bartz2008-egstar.pdf

Design helpful interfaces

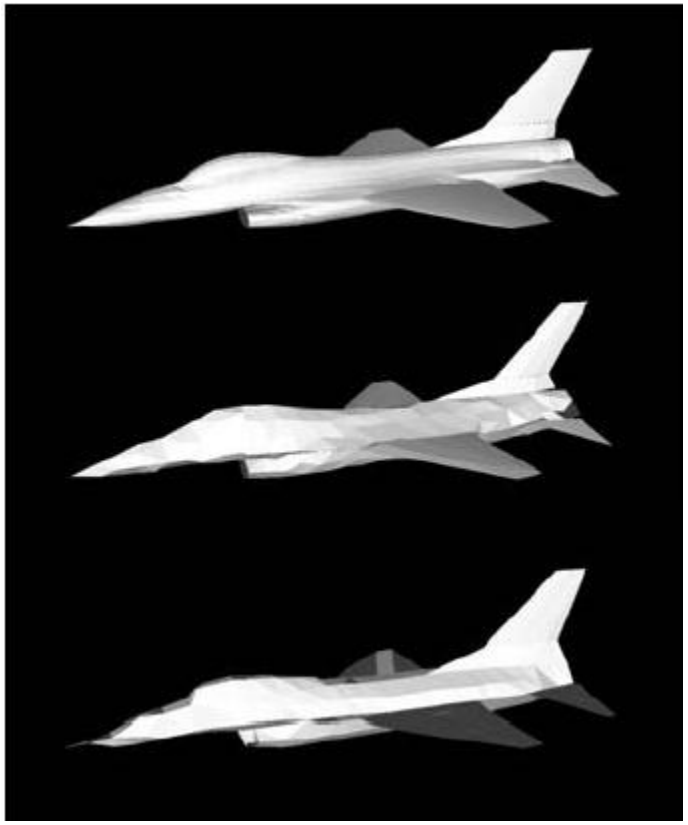
Why Bother?



http://www.gib.uni-tuebingen.de/own/journal/img/upload/b5c7411768af926eac4b17fc70foeb7d.png

Communicate effectively

Why Bother?



What types of objects can be simplified?

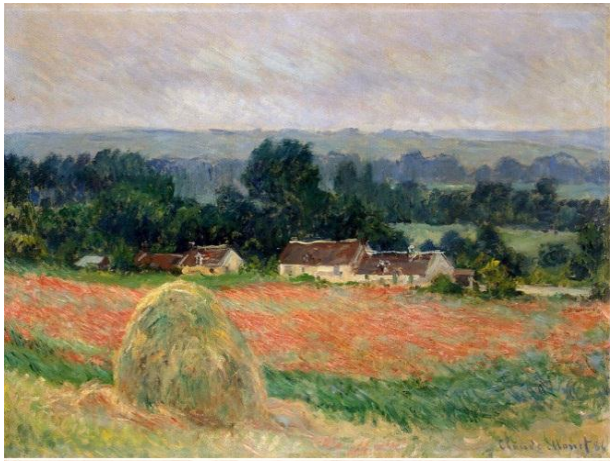
What is the best simplification method?

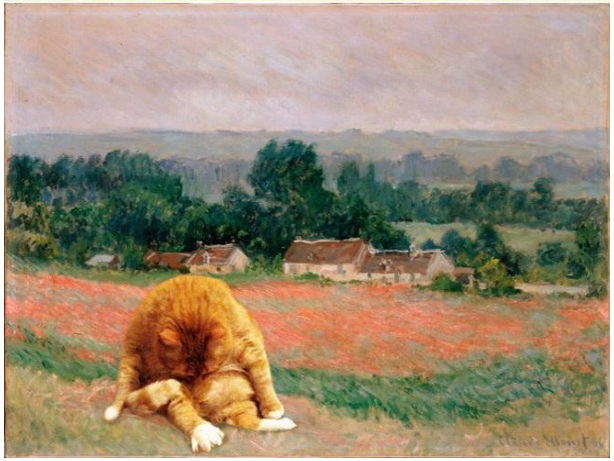
How will simplification affect brain processing time?

http://isg.cs.tcd.ie/oconork/papers/Perceptually%20Adaptive%20Graphics.pdf

Know what matters

Why Bother?





http://imgur.com/a/K4wsg

Combine content from multiple images

http://www.mcescher.com/Biography/lw439f14.jpg

Perception

CS 148, Summer 2012
Introduction to Computer Graphics and Imaging

Justin Solomon