Introduction to Human Vision System (HVS)

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Understanding HVS, Why?

- Image or video is to be seen.
- Perceptual Based Image Processing
  - Focus on perceptually significant information
  - Discard perceptually insignificant information
- Issues:
  - Biological
  - Psychophysical

Anatomy of Human Eye

choroid脉络膜

retina视网膜

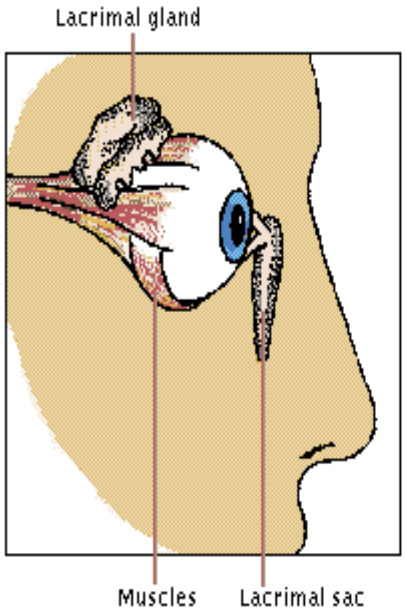
Cornea 角膜

Aqueous humor眼房水

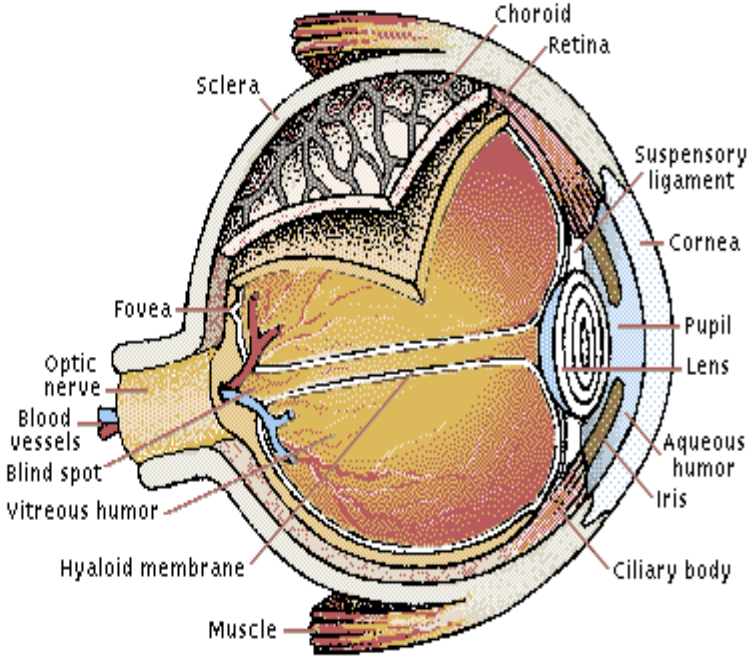
Fovea 黄斑

Vitreous humor玻璃体

ciliary body睫状体



Microsoft Illustration



The amount of light entering the eye is controlled by the pupil, which dilates and contracts accordingly. The cornea and lens, whose shape is adjusted by the ciliary body, focus the light on the retina, where receptors convert it into nerve signals that pass to the brain. A mesh of blood vessels, the choroid, supplies the retina with oxygen and sugar.
http://psych.athabascau.ca/html/Psych402/Biotutorials/22/intro.shtml

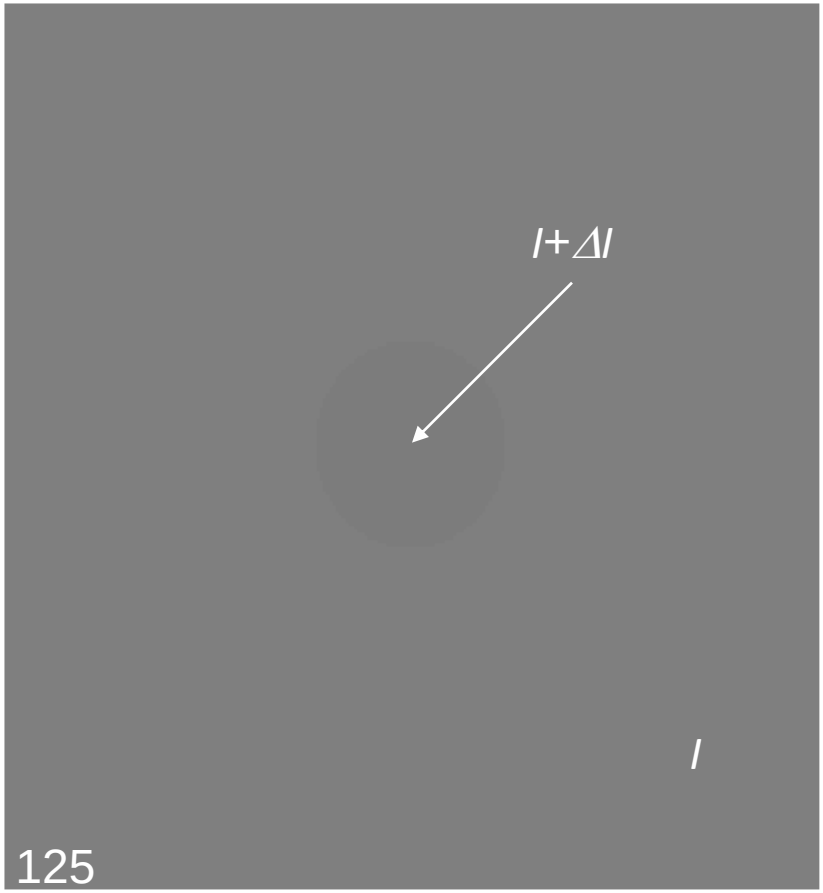
Visual Psychophysics

- Model vision "system" as an input-output system
  - visual stimuli: input
  - prescribed sensations: output.
- Visual psychophysics:
  - Characterize the response of HVS to different stimuli

Brightness Discrimination

- Can you see the circle?
- ΔI is the just noticeable difference (JND) [1].
- Weber's Law:

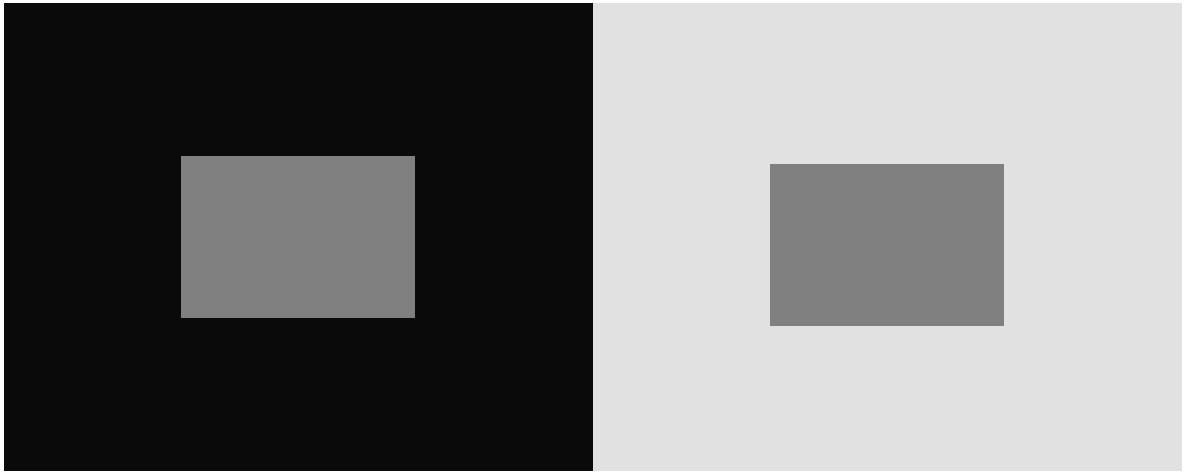
$$\frac{\Delta I}{I} \approx const$$



This rule is first discovered by Ernst Heinrich Weber (1795-1878), an anatomist and physiologist.

Luminance and Brightness

- **Luminance** measures physical light intensity.
- The perceived intensity, or **brightness**, depends upon the luminance of both the object and the background.



The illusion of simultaneous contrast

The luminance of both center objects is the same

Contrast

- The contrast is the ratio between the brightest intensity level and the dimmest.

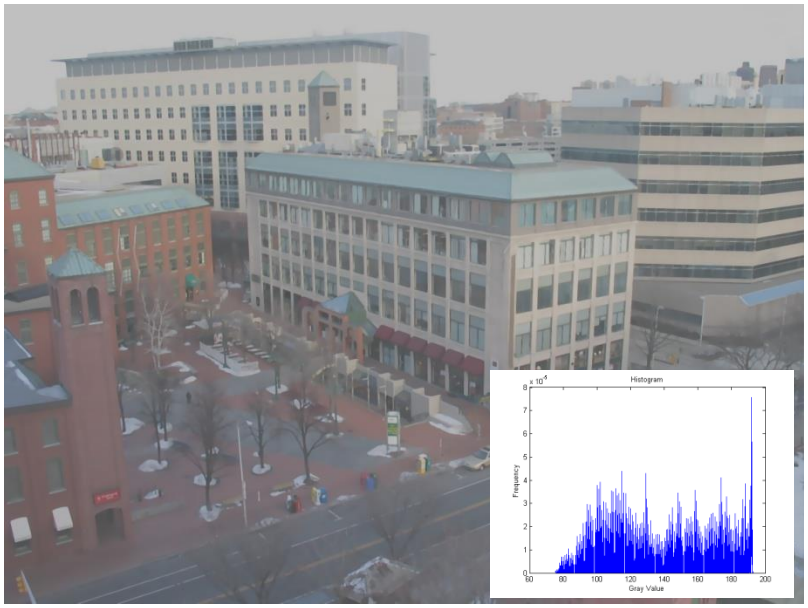
$$C = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \qquad 0 \leq C \leq 1$$

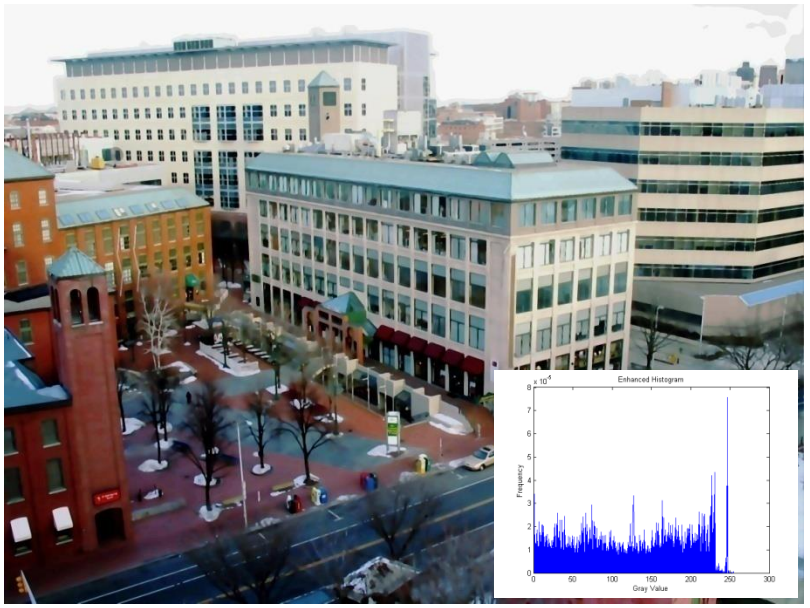
- Low contrast image has “closely spaced” distribution of intensity values (i.e., contrast close to 0)
- High contrast image has “widely spaced” distribution of intensity values (i.e., contrast close to 1)

Low Contrast vs. High Contrast

Enhance Contrast Using Histogram Equalization

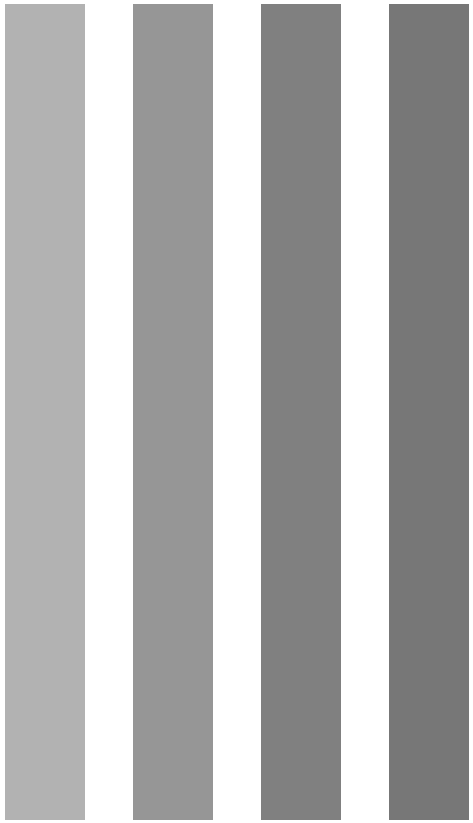
Low Contrast vs. High Contrast



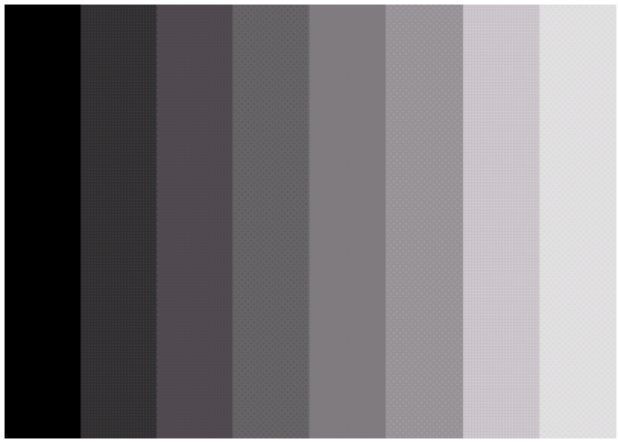


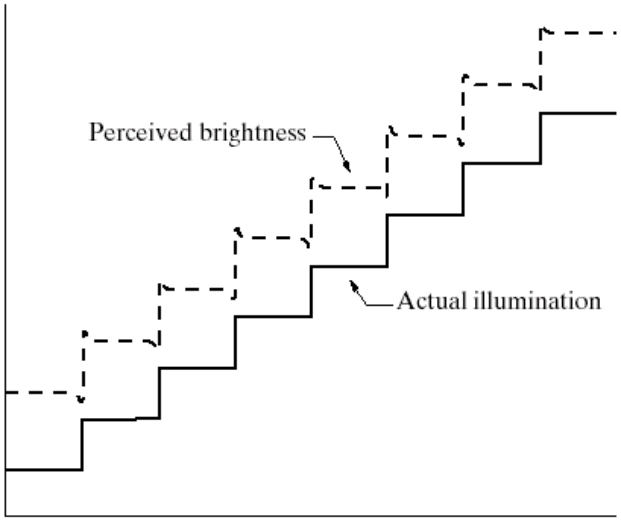
Applying Histogram Equalization to RGB color channels independently

Mach Band Effect [2]

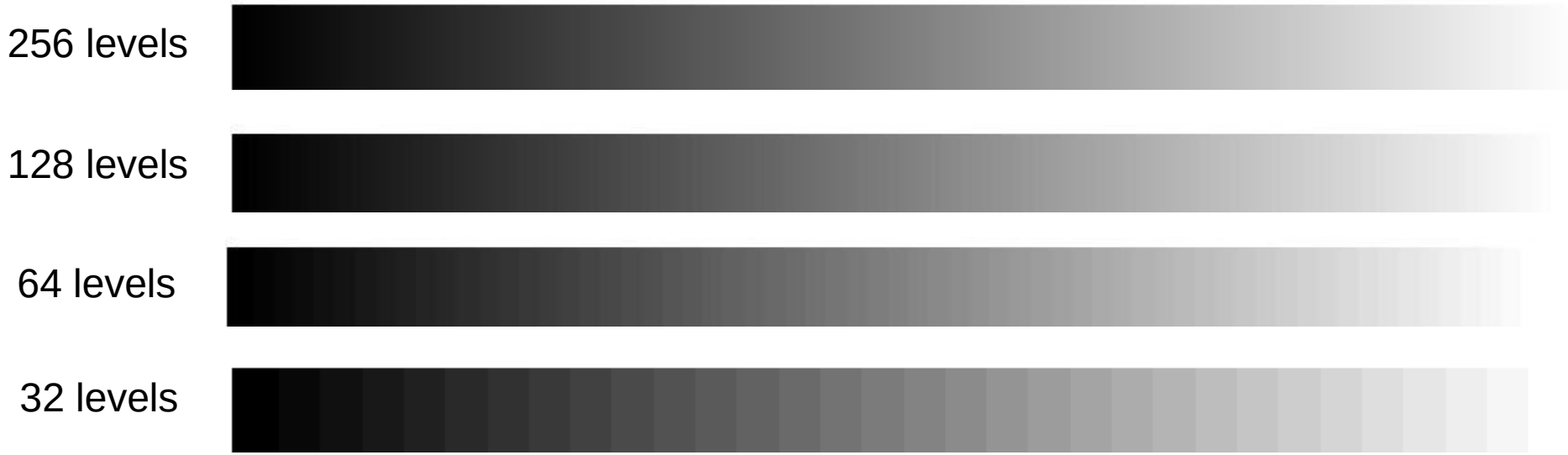


- Note that each bar on the left appears to have color variation across it
  - Left edge appears darker than right
- The effect is entirely due to Mach banding





Why 8-bit/pixel for standard gray image?

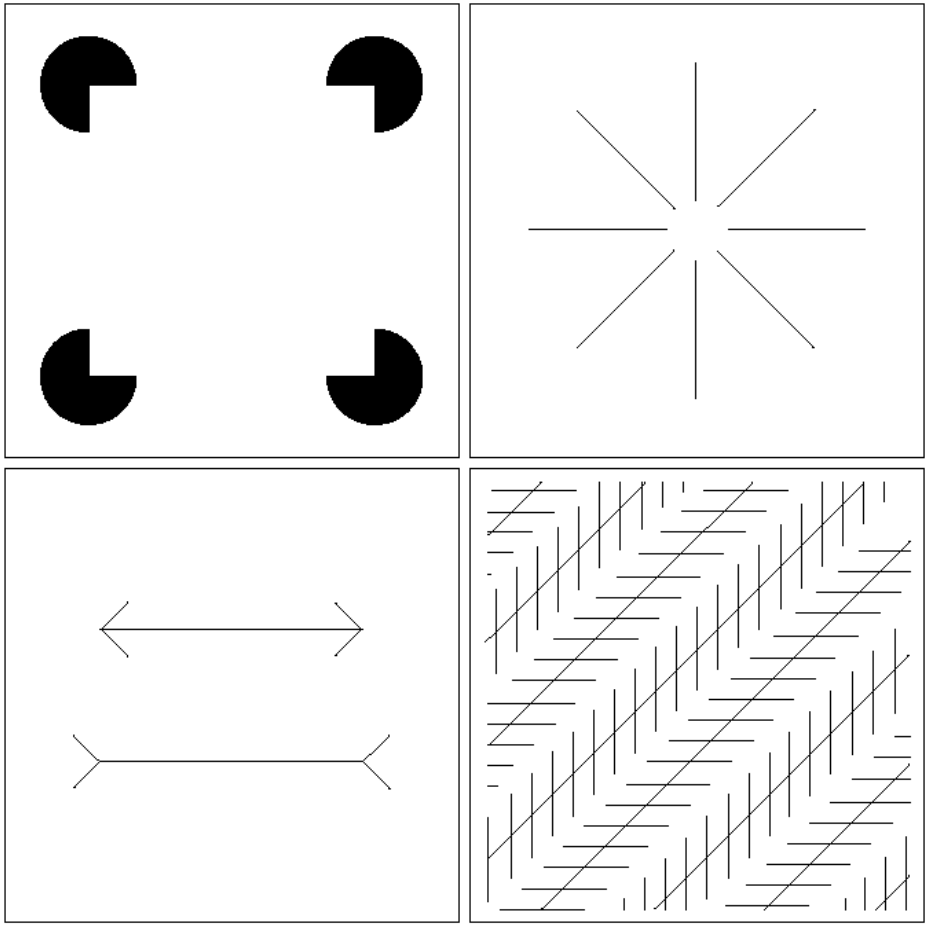


- Digital images are typically quantized to 256 gray levels.

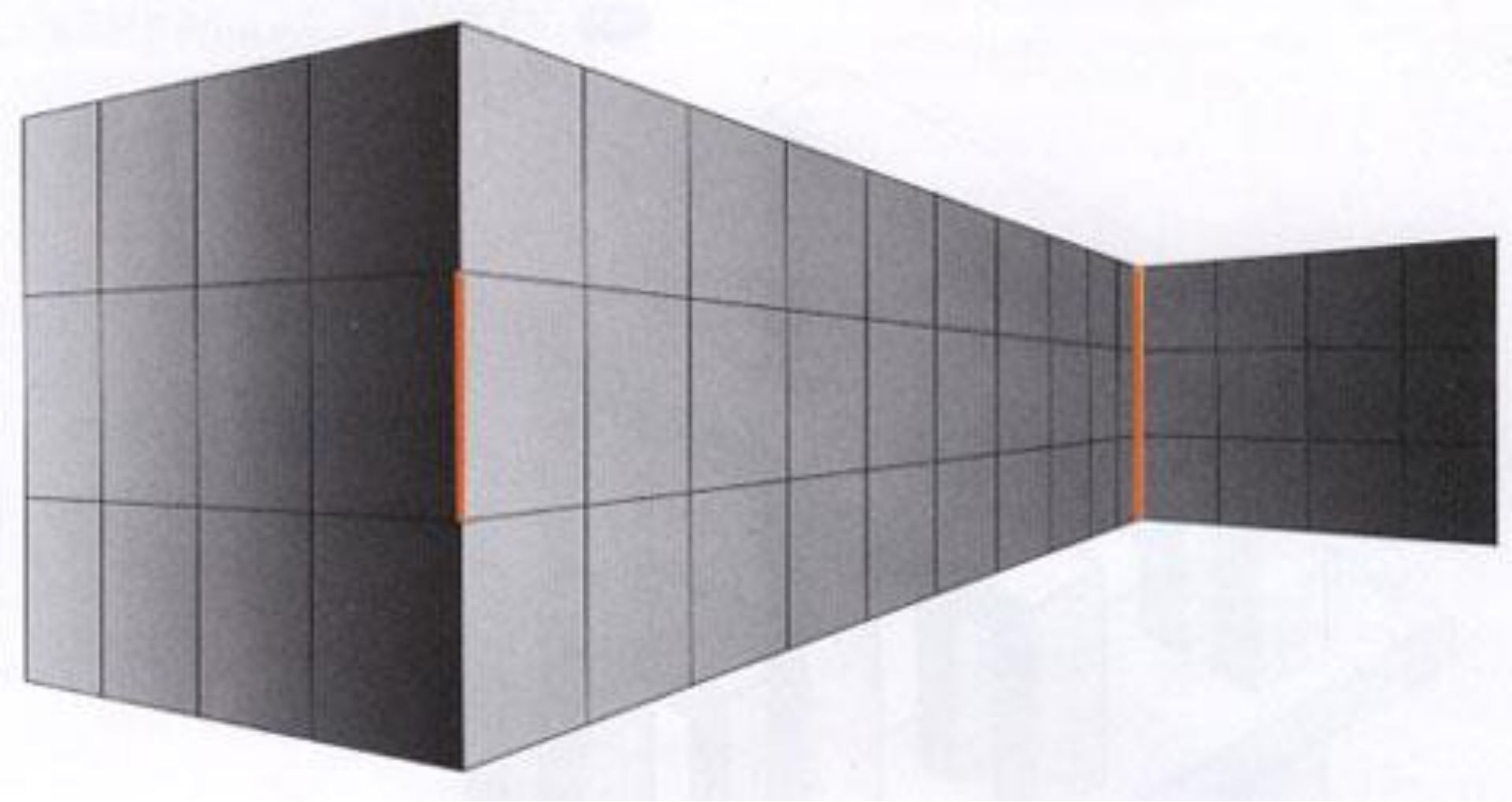
Optical Illusions

a b
c d

FIGURE 2.9 Some well-known optical illusions.

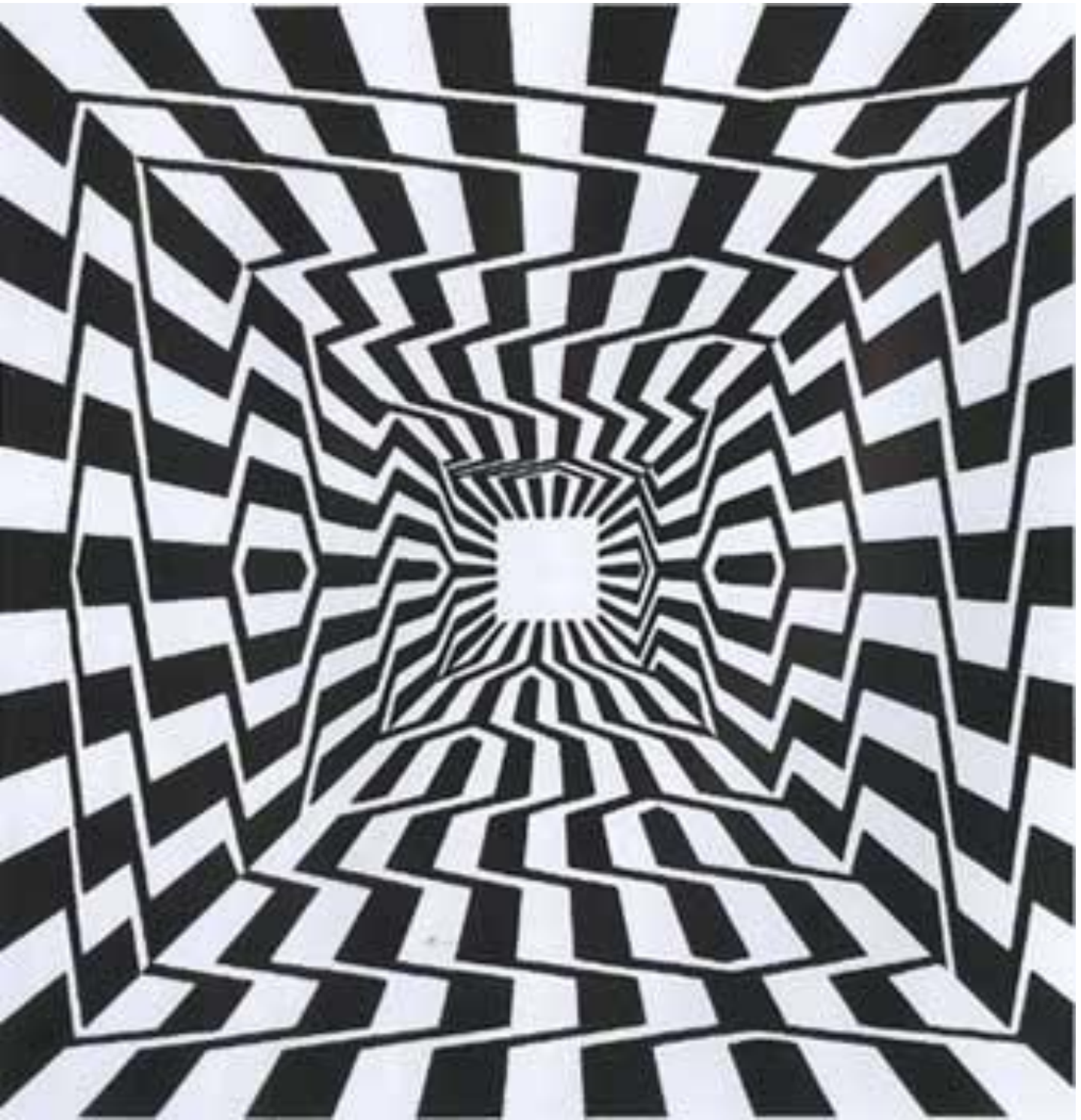


Rubin's Vase Illusion or Figure-Ground Vase

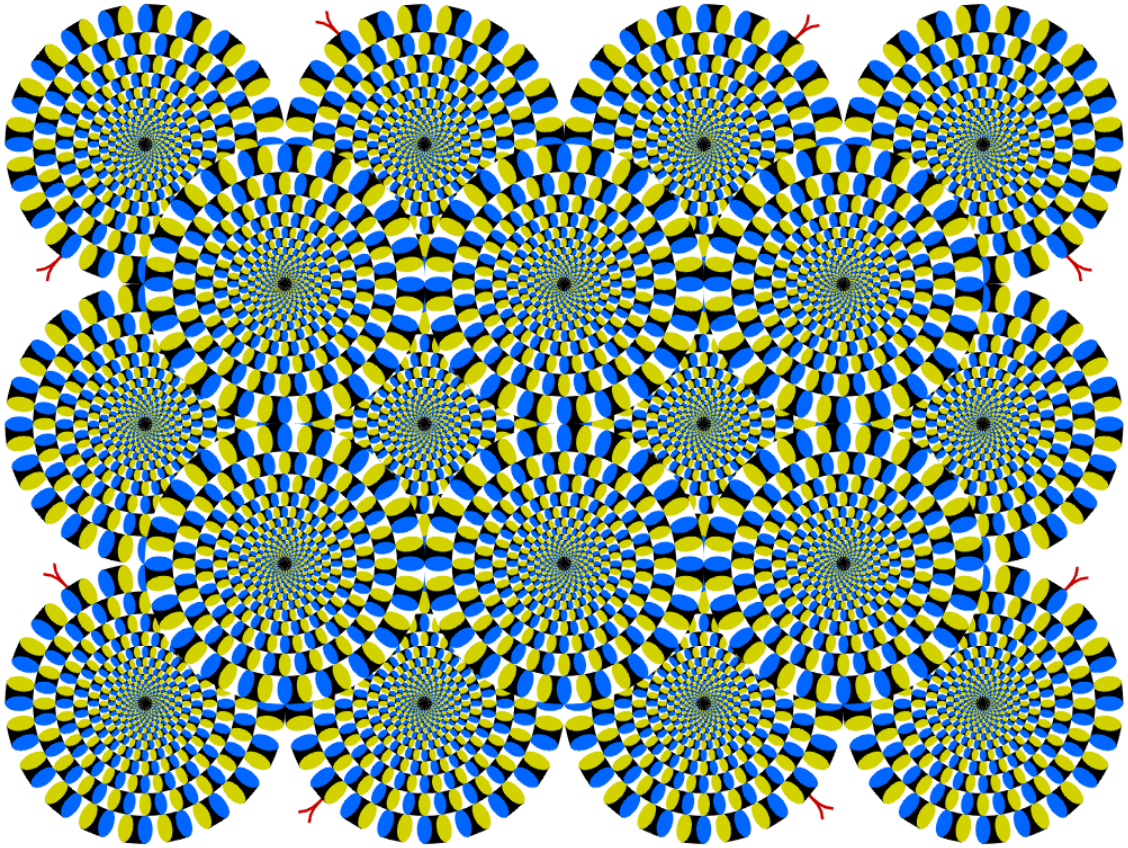


Müller-Lyer Illusion： Which red line is longer?
Actually these two red lines are with equal length

Are these perfect squares?



Anomalous Motion Illusion [3]



http://www.ritsumei.ac.jp/~akitaoka/index-e.html

References

- [1] http://apps.usd.edu/coglab/WebersLaw.html
- [2] http://en.wikipedia.org/wiki/Mach_bands
- [3] http://www.ritsumei.ac.jp/~akitaoka/index-e.html

Thank You!

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