

Principles of Digital Imaging

Sampling and Quantization of Digital Image

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1

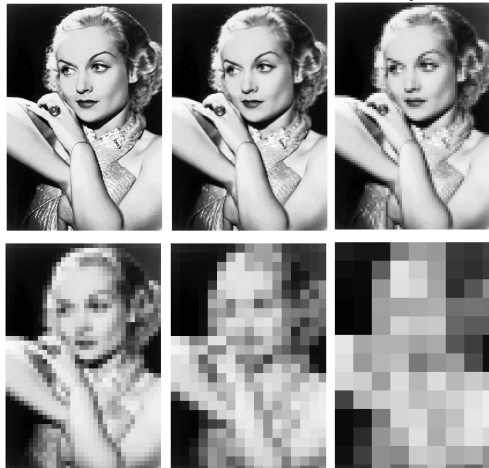
Contents

- Sampling of Image
- Quantization of Image
- Information Capacity of Image
- Sampling and Quantization by Human Visual System

2

Sampling of Image

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11

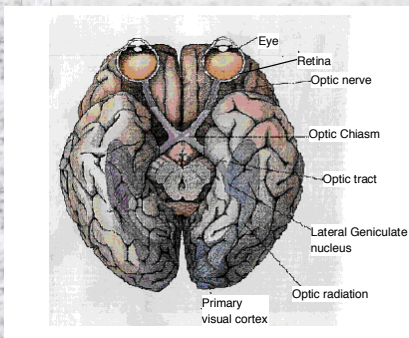
Quantization of Image

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20

Human visual information processing



- Eye balls: Camera
- Retina: High intelligent input device
 - High sensitive sensor (rods and cones)
 - Luminance channel and chromatic channel (horizontal cells)
 - Contrast (ganglion cells)
- LGN: M-path (where), P-path (what)
 - Shape, motion, color, detail
- Visual cortex

Retina of a living human eye (1)

(David Williams, in *Optics & Photonics News*, vol.9, no.1, 1998)

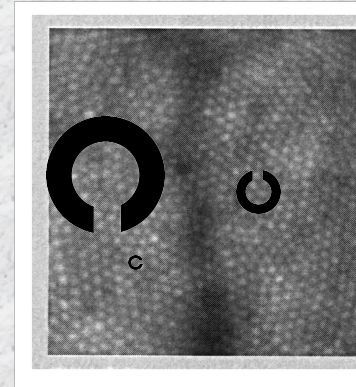
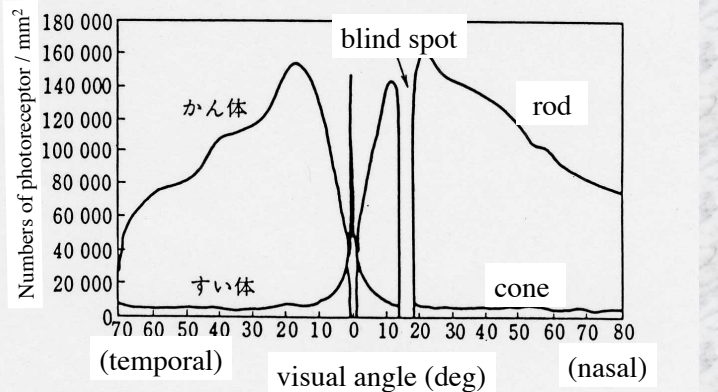


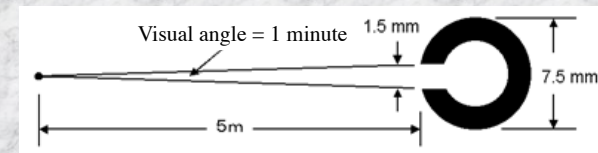
Figure 8. The retina of a living human eye taken after adaptive optical correction of the eye's optical system. The image, taken with 550 nm light, is a registered sum of 61 images taken over four days. Image size is 0.5 X 0.5 degrees (146 X 146 μm). The bright spots in the image are cone photoreceptors, each on the order of 5 μm. The darker vertical band down the center of the image is a shadow of a capillary that when focused on, is about 5 μm in diameter. The retinal location of the image is about 1° from the central fovea. The only filtering used was histogram equalization to enhance contrast.

$$900 \text{ cones} / 0.021 \text{ mm}^2 = 42,800 \text{ cones/mm}^2$$

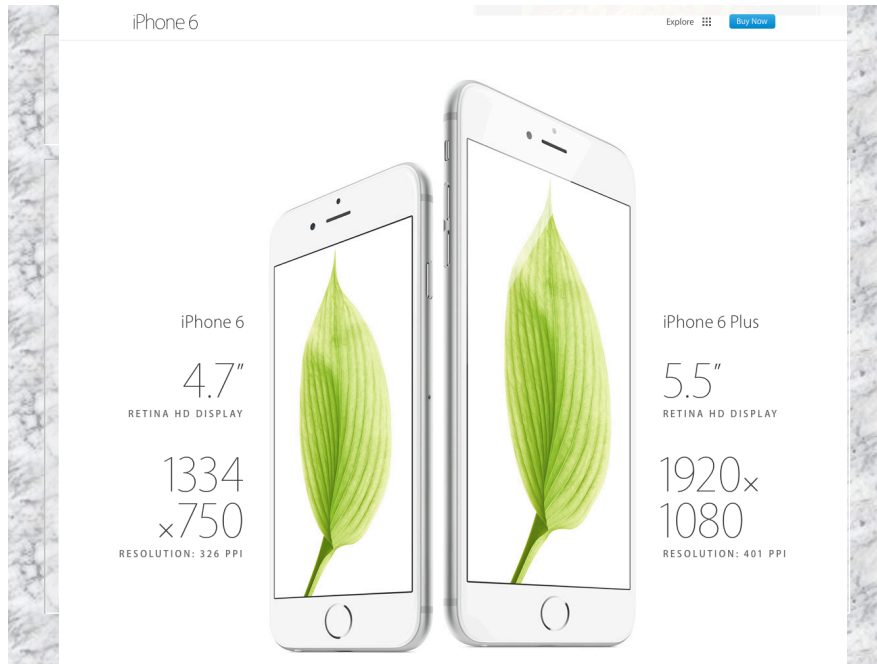
Density of rods and cones in a retina



Spatial resolution of visual system



Visual acuity = $1/\theta$
 θ (min): the smallest visual angle discriminatable



Relation between visual acuity and the number of pixels in image

- Density of cones 120 cones/deg
- Observed from distance of 30 cm
 - 1 deg corresponds to 5.23mm
 - 23.5(=120/5.23) cones per mm
 - 23.5 dot/mm = 600 dpi (dot per inch)
 - L size (89x127) 17°x24.3° → 2,040x2,916 = 5.9Mpixels
 - A4 size (210x297) 40°x56.7° → 4,812x6,804 = 32.7 Mpixels
 - iPhone(74x50) 14°x9.5° → 1,680x1,140=1.9 Mpixels

iPhone 6: 1,334 x 750 (326ppi)
 iPad mini 2, 3: 2,048 x 1,536 (326ppi)
 iPad mini: 1,024 x 768 (163 ppi)
 MacBook Pro 13': 2,560 x 1,600 (227 ppi)

27

Retina of a living human eye(2)

(Roorda and Williams, *Nature*, 397, 520-522, 1999)

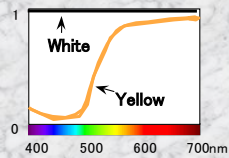
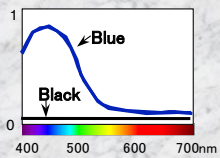
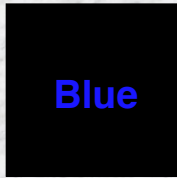
Figure 3 Pseudocolour image of the trichromatic cone mosaic. Blue, green and red colours represent the S, M and L cones, respectively. **a**, **b**, Subject JW's temporal and nasal retina, respectively, at one degree of eccentricity. **c**, Subject AN's nasal retina, at one degree of eccentricity. We performed a statistical test for randomness according to Diggle¹⁷. We compared the distribution of all intercone distances of the measured M-cone array with 100 simulations derived from the same mosaic in which the same number of M cones were randomly assigned. JW's array was no different from random at either location. AN's array showed significant clumping of the data ($P < 0.01$) but, because of optical blur, the possibility of a random assignment of M cones cannot be ruled out. Scale bar represents 5 arcmin of visual angle.

29

Photoreceptors (Cones)

30

Blue and Yellow

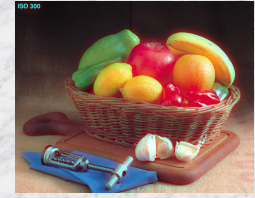


Effects of Gaussian Blur in RGB

original



Red image blurred



Green image blurred



Blue image blurred