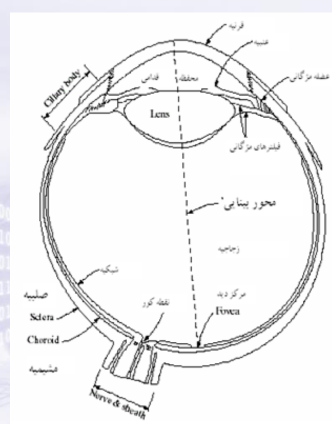
تجزیه وتحلیل داده ها در نساجی

پردازش تصویر

دکتر پدرام پیوندی

بخش دوم

ساختار چشم انسان



قرنیه قسمت شفاف جلوی کره چشم است

عنبیه بخش رنگی پشت قرنیه است که رنگ چشم را تعیین می کند

اتاق قدامی فضای کوچکی است که بین قرنیه و عنبیه قرار دارد.

عدسی یک ساختمان شفاف در پشت عنبیه است که در متمرکز کردن دقیق پرتوهای نور بر روی شبکیه به قرنیه کمک می کند.

زجاجیه مایع ژله مانند شفافی است که داخل کره چشم را پر می کند و به آن شکل می دهد.

شبکیه یک پرده نازک حساس به نور (شبیه فیلم عکاسی) است که در عقب کره چشم قرار دارد

مشیمیه پرده نازک سیاه رنگی است که دور شبکیه را احاطه کرده است.

صلبیه بخش سفید رنگ نسبتاً محکمی است که دورتا دور کره چشم به جز قرنیه را می پوشاند

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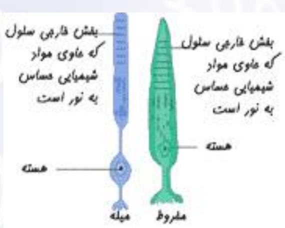
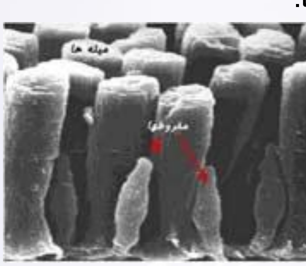
3

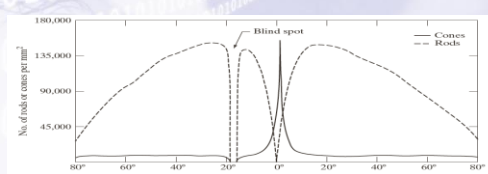
ساختار چشم انسان



گیرنده های نوری - مخروط‌ها و میله ها

گیرنده های نوری شبکیه به دو دسته تقسیم می‌شوند، مخروط‌ها و میله ها.
این نام گذاری بر اساس شکل تقریبی مقطع عرضی این گیرنده‌ها
زیر میکروسکوپ انجام شده است. میله‌ها مسئول بینایی ما در شب هستند
و مخروط ها بینایی رنگی ما را در روز تأمین می‌کنند.
بیش از صد میلیون گیرنده میله ای در شبکیه وجود دارد.
بیش از شش میلیون گیرنده مخروطی در شبکیه وجود دارد.
مخروط‌ها و میله ها، تصویر با میکروسکوپ الکترونی تهیه شده است.
قسمت های مختلف سلول های مخروطی و میله ای





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4

ساختار چشم انسان

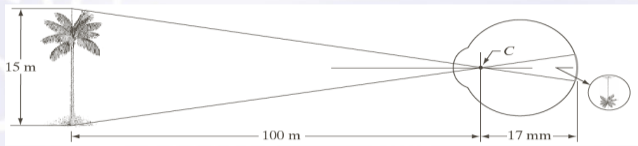
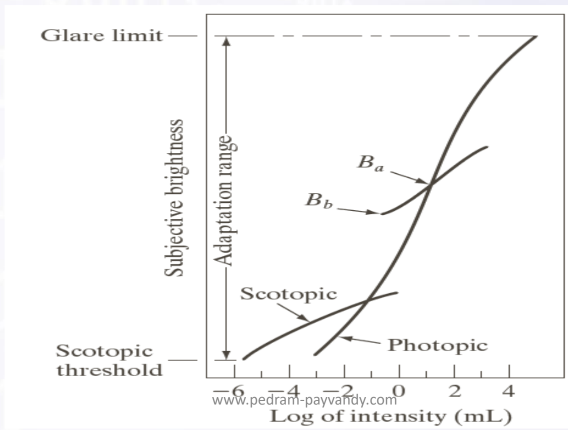


FIGURE 2.3 Graphical representation of the eye looking at a palm tree. Point C is the optical center of the lens.



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ساختار چشم انسان

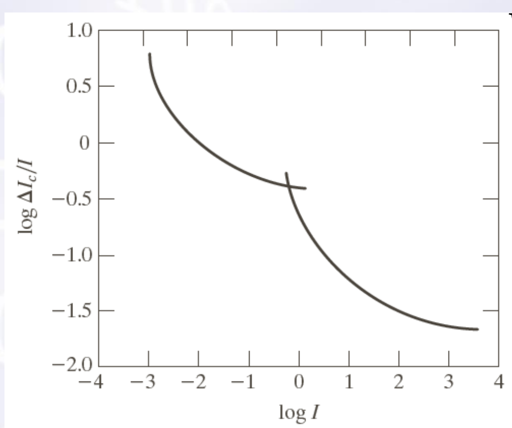
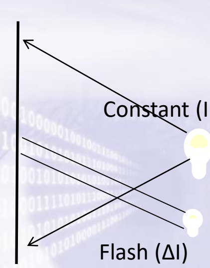


FIGURE 2.6 Typical Weber ratio as a function of intensity.

$$WeberRatio = \Delta I_c / I$$



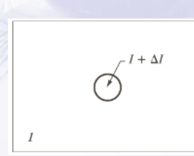


FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

6

مطالعه آزاد

چرا جراحان لباس سبز یا آبی می‌پوشند؟

جراحان در قدیم لباس سفید می‌پوشیدند زیرا سفید را رنگ پاکی می‌دانستند. اما براساس مقاله‌ای که یکی از شماره‌های نشریه Today's Surgical Nurse در سال ۱۹۹۸ چاپ کرد، در اوایل قرن بیستم یک پزشک مشهور رنگ لباسش را به سبز تغییر داد زیرا تصور می‌کرد این رنگ برای چشمان جراح راحت‌تر است.

اگرچه مشکل می‌توان این نظر را تایید کرد که لباس‌های سبز به این دلیل رایج شده‌اند اما رنگ سبز ممکن است بخصوص از این لحاظ مناسب باشد که به پزشکان کمک می‌کند در اتاق عمل بهتر ببینند زیرا رنگ متضاد یا مکمل رنگ قرمز به حساب می‌آید. رنگ سبز به ۲ دلیل به دید بهتر پزشکان کمک می‌کند؛ اول اینکه نگاه کردن به رنگ سبز یا آبی می‌تواند دید پزشک به اشیای قرمز از جمله احشای خون‌آلود را تقویت کند زیرا مغز رنگ‌ها را نسبت به یکدیگر تفسیر می‌کند. اگر جراح به چیزی خیره شود که به رنگ قرمز یا صورتی باشد، حساسیتش را نسبت به آنها از دست می‌دهد. در واقع پیام‌های مربوط به رنگ قرمز در مغز محو می‌شود که می‌تواند باعث عدم درک تفاوت‌های ظریف رنگ در اجزای بدن توسط پزشک گردد.

دوم اینکه چنین تمرکز شدید و مداومی بر رنگ قرمز، شاید باعث توهمات بینایی سبزرنگ روی سطوح سفیدرنگ شود که حواس جراح را پرت می‌کند. این شبح‌های سبزرنگ در صورتی که نگاه جراح از بافت‌های قرمز بدن به چیزی سفیدرنگ مانند پارچه‌های تخت یا لباس سفید بیفتد، ممکن است ظاهر شوند.

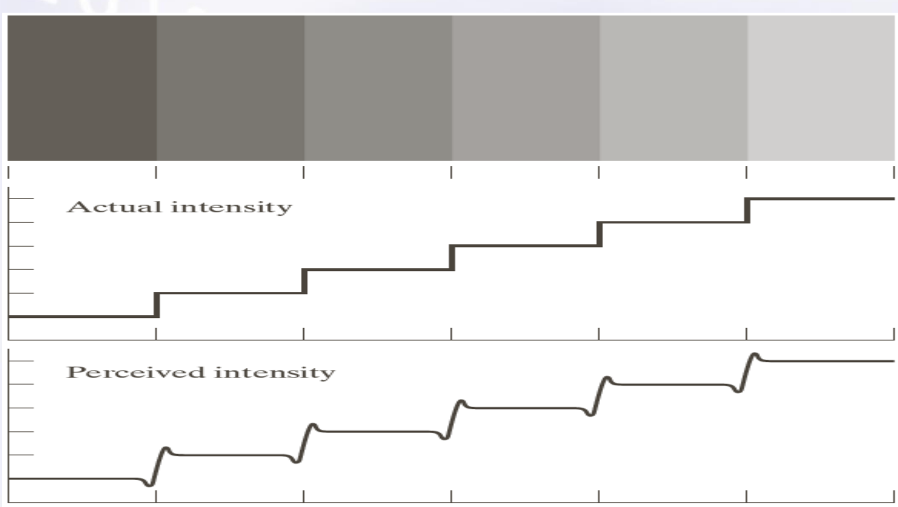
ممکن است یک شبح سبزرنگ از احشای قرمز بیمار روی پس زمینه سفید ظاهر شود. جراح به هر جا که نگاه کند، این تصویر پریشان‌کننده مانند نقاط نورانی شناوری که پس از فلاش زدن دوربین جلوی چشمان شما ظاهر می‌شود، دید او را دنبال می‌کند؛ این پدیده به این علت رخ می‌دهد که نور سفید حاوی همه رنگ‌های رنگین کمان از جمله سبز و قرمز است.

اما همان‌طور که در بالا گفته شد، دید جراح حساسیتش را به رنگ قرمز از دست داده است، بنابراین مغز پیام‌های دریافتی را به رنگ سبز تفسیر می‌کند ولی اگر به پارچه‌های سبز یا آبی یا محلی سفیدرنگ نگاه کند، این اشباح سبزرنگ با رنگ سبز مخلوط می‌شوند و حواس او را پرت نمی‌کنند.

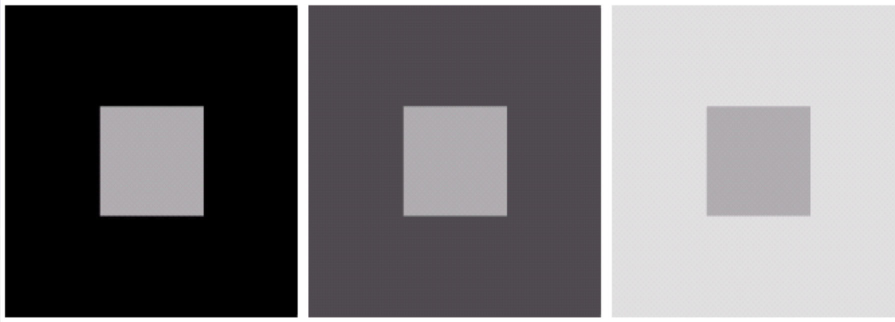
• همشهری آنلاین

۱۳
ل-شماره اول-شهریور ۸۸

انطباق وجداسازی روشنایی



انطباق وجداسازی روشنایی



a b c

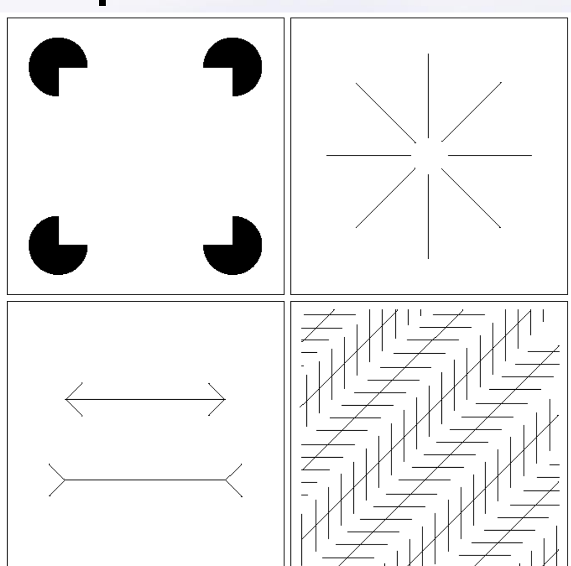
FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

9

خطاهای سیستم بینایی

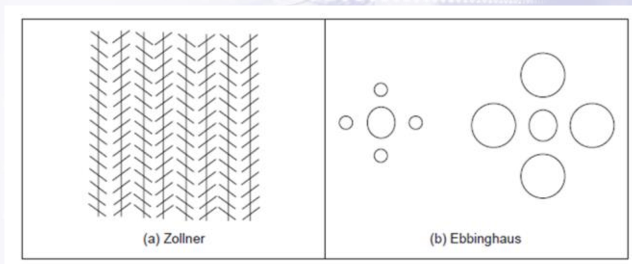
a b
c d

FIGURE 2.9 Some well-known optical illusions.



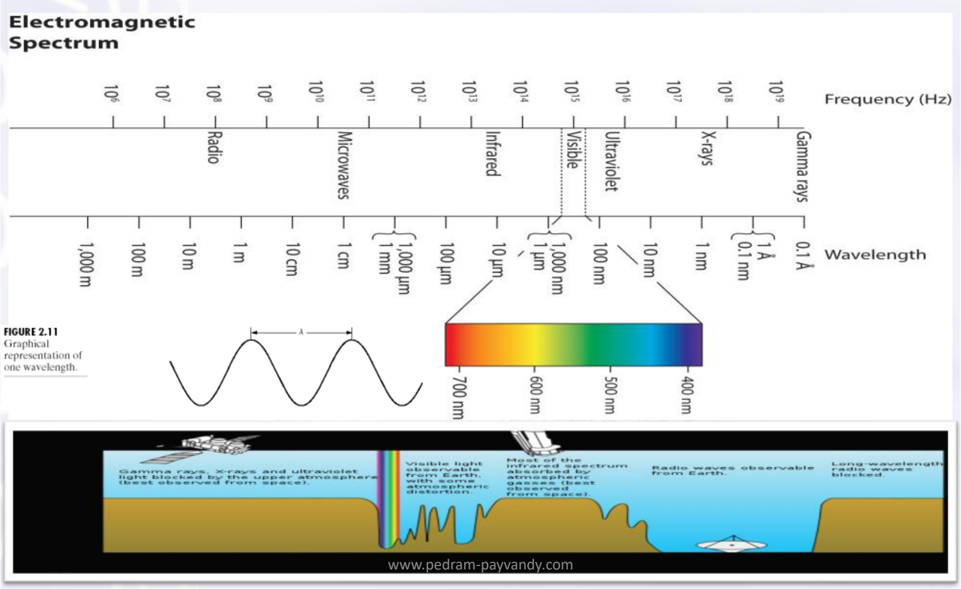
10

خطاهای سیستم بینایی

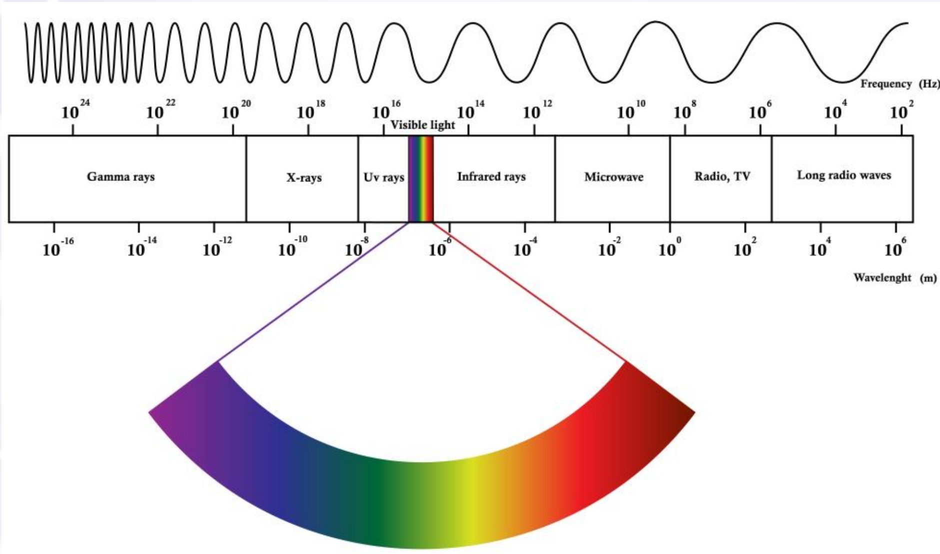


11

طیف الکترو مغناطیسی نور



12



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13

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14

HOW THE RANKINGS WORK: Humans are 0/0/0 on this chart and act as a point of reference. A 100 means that the animal is the best in that field compared to any other animal of their class, except in the case of field of vision. Since many animals have 360 degrees of vision, they all get 100.

DISTANCE

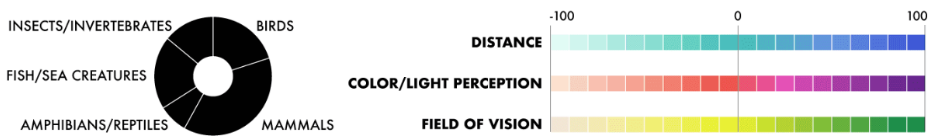
The distance measure ranks how far animals can see compared to humans. This includes the ability to see prey in the dark, spot movement, and recognize patterns and shapes from a distance. So a higher score may not necessarily mean they can see the farthest, just that their eyes are more versatile across distances than humans.

COLOR/LIGHT PERCEPTION

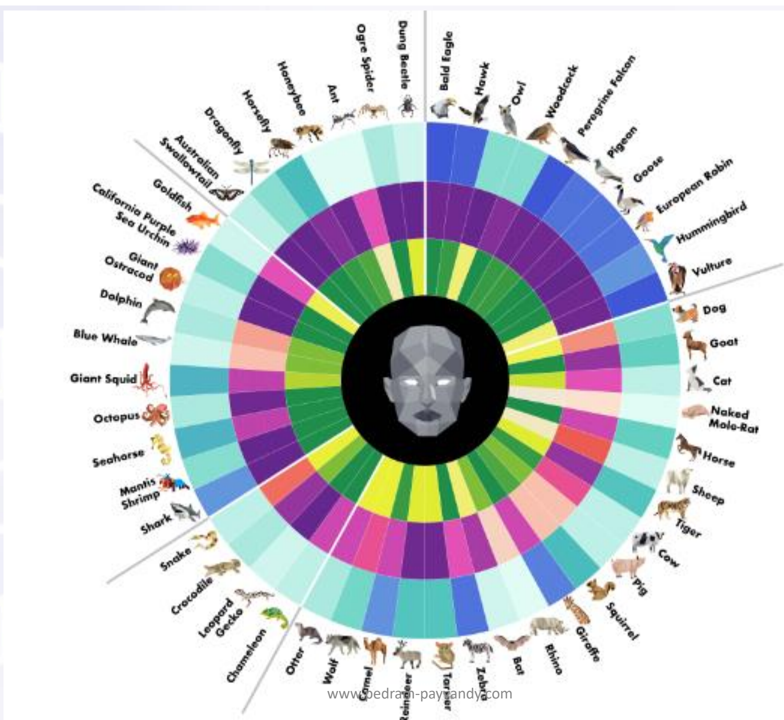
The color/light perception measure ranks how well animals see in the dark and how many colors they can perceive compared to humans. The visible spectrum humans can see falls between ultraviolet light and red light. Humans typically have three types of photo pigments in their cones: red, green, and blue. This allows them to distinguish up to 10 million colors. Up to 12% of human females have four cone types, which enables them to perceive 100 times more colors. Many birds, insects, and fish have four cones, which enables them to see ultraviolet light. Ultraviolet light has shorter wavelengths than humans can perceive. Other animals, such as dogs, have fewer types and numbers of cones, which reduces how many colors they can perceive.

FIELD OF VISION

The field of vision measure ranks how the peripheral vision of animals compares to humans. Peripheral vision is how well you can see above, below, and to the sides of where your gaze is fixed. Eyes on the sides of the head typically allow for a wider field of vision. Prey animals and herbivores tend to have eyes on the sides of their head, enabling them to notice predators sneaking up on them. Most predators have front-facing eyes, which gives them a larger binocular visual field (where both eyes can see clearly together), helping them pinpoint and lock on prey over distances. If an animal has a field of vision of 360 degrees, they get 100 points.

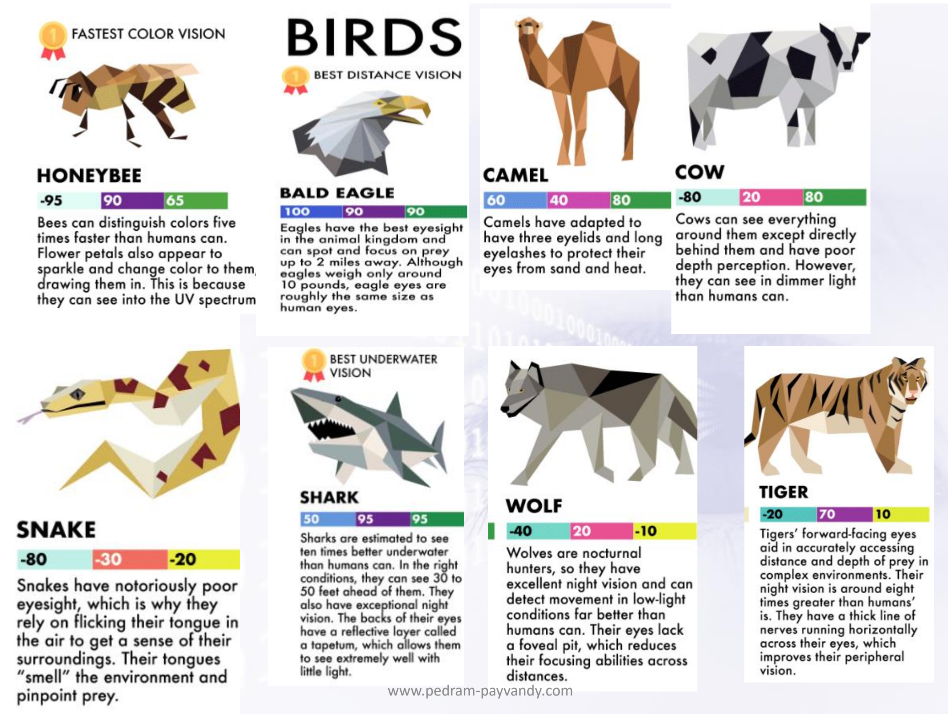


15



https://www.lasikbyoclivision.com/90-animals-ranked-by-eyesight/

16


FASTEST COLOR VISION
HONEYBEE
-95 90 65
Bees can distinguish colors five times faster than humans can. Flower petals also appear to sparkle and change color to them, drawing them in. This is because they can see into the UV spectrum
BIRDS
BEST DISTANCE VISION
BALD EAGLE
100 90 90
Eagles have the best eyesight in the animal kingdom and can spot and focus on prey up to 2 miles away. Although eagles weigh only around 10 pounds, eagle eyes are roughly the same size as human eyes.
CAMEL
60 40 80
Camels have adapted to have three eyelids and long eyelashes to protect their eyes from sand and heat.
COW
-80 20 80
Cows can see everything around them except directly behind them and have poor depth perception. However, they can see in dimmer light than humans can.
SNAKE
-80 -30 -20
Snakes have notoriously poor eyesight, which is why they rely on flicking their tongue in the air to get a sense of their surroundings. Their tongues "smell" the environment and pinpoint prey.
BEST UNDERWATER VISION
SHARK
50 95 95
Sharks are estimated to see ten times better underwater than humans can. In the right conditions, they can see 30 to 50 feet ahead of them. They also have exceptional night vision. The backs of their eyes have a reflective layer called a tapetum, which allows them to see extremely well with little light.
WOLF
-40 20 -10
Wolves are nocturnal hunters, so they have excellent night vision and can detect movement in low-light conditions far better than humans can. Their eyes lack a foveal pit, which reduces their focusing abilities across distances.
TIGER
-20 70 10
Tigers' forward-facing eyes aid in accurately accessing distance and depth of prey in complex environments. Their night vision is around eight times greater than humans' is. They have a thick line of nerves running horizontally across their eyes, which improves their peripheral vision.
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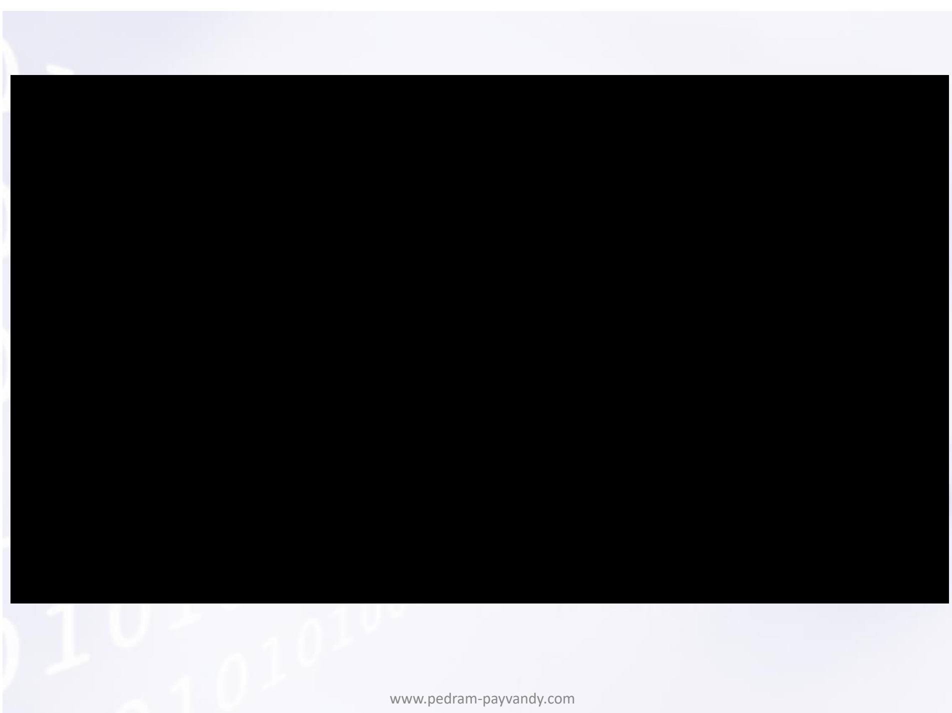
17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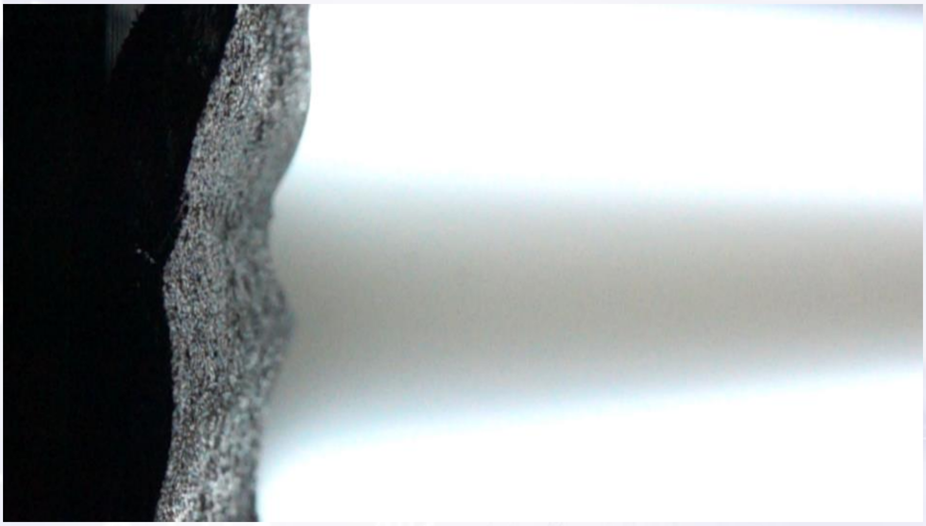
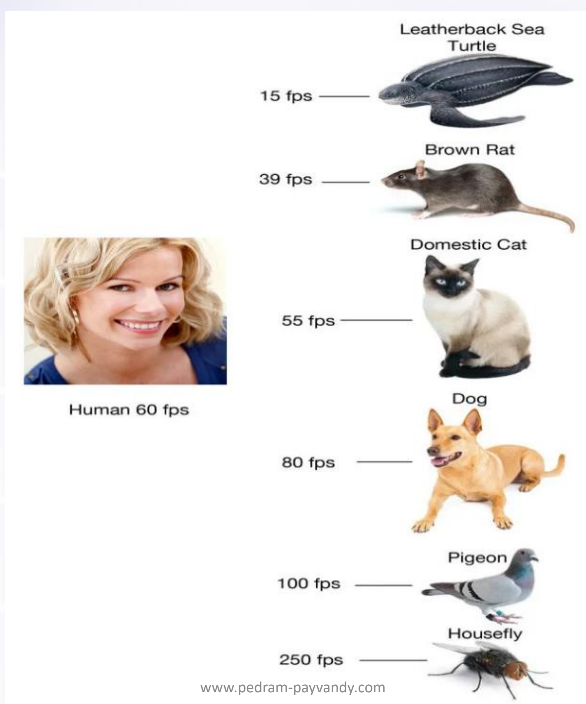
18



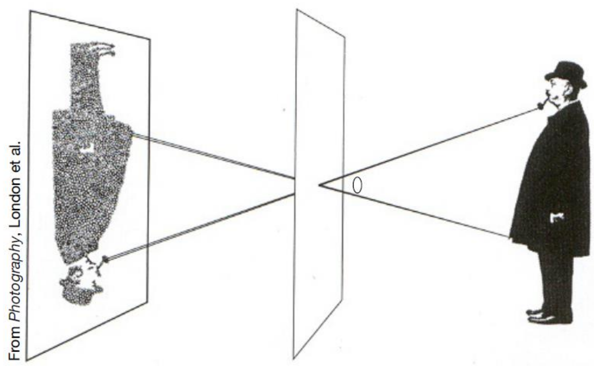
19


Leatherback Sea Turtle
15 fps
Brown Rat
39 fps
Domestic Cat
55 fps
Human 60 fps
Dog
80 fps
Pigeon
100 fps
Housefly
250 fps

20

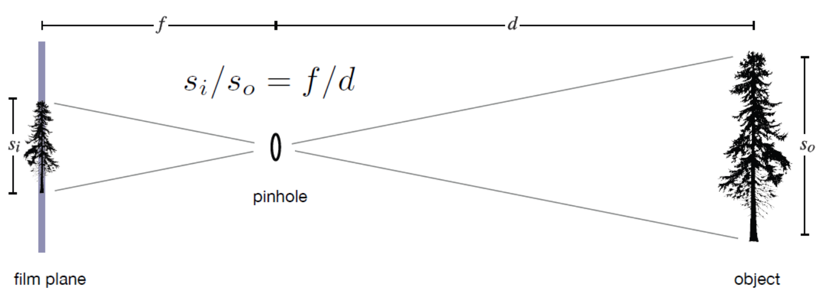
Pinhole camera

- **Simplest possible camera**
  1. light tight box with hole
  2. film
- **Rays are selected simply by occlusion**



Worth a look
www.kodak.com/ek/US/en/Pinhole_Camera.htm

"Focal" length



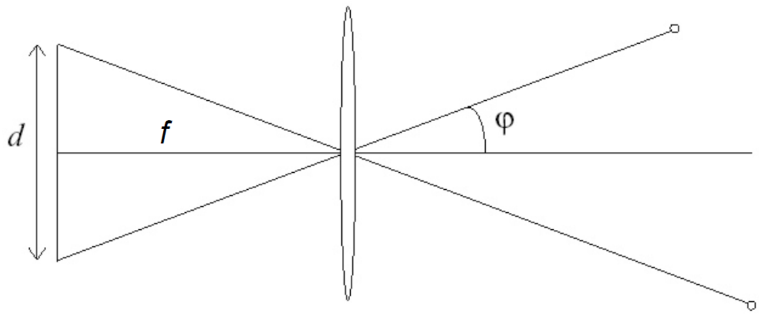
- **Double "focal length" leads to**

  image twice as large

  one fourth as much illumination at image plane

tree image: NRC Canada

FOV depends of Focal Length



Size of field of view governed by size of the camera retina:

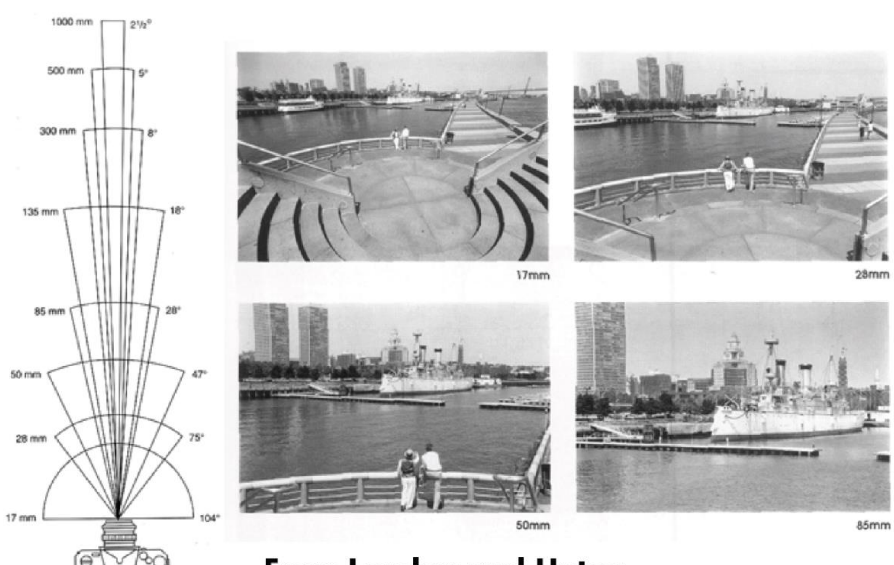
$$\varphi = \tan^{-1}\left(\frac{d}{2f}\right)$$

Smaller FOV = larger Focal Length

slide by Alyosha Efros, CMU

23

Changing FOV—viewpoint constant

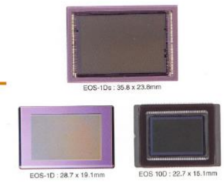


From London and Upton

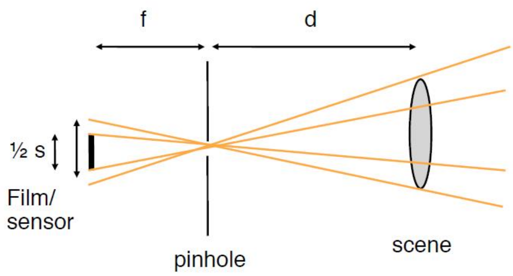
slide by Alyosha Efros, CMU

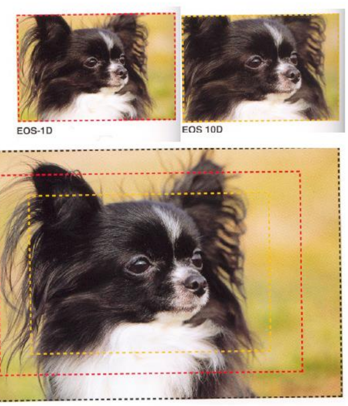
24

Focal length & sensor



- **What happens when the film is half the size?**
- **Application:**
  - Real film is 36x24mm
  - On the 10D, the sensor is 22.5 x 15.0 mm
  - Conversion factor on the 20D?
  - On the SD500, it is 1/1.8 " (7.18 x 5.32 mm)
  - What is the 7.7-23.1mm zoom on the SD500?



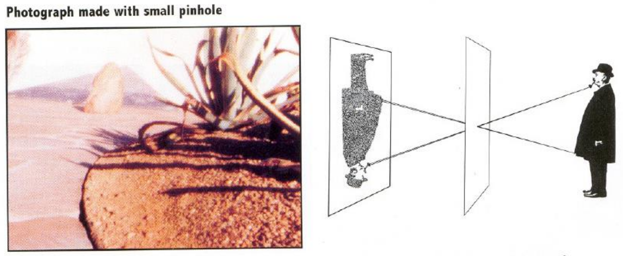


slide by Frédo Durand, MIT

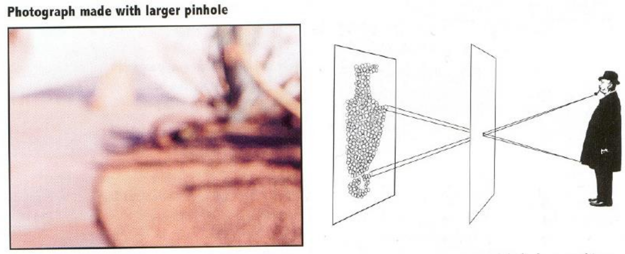
25

Effect of pinhole size

Photograph made with small pinhole



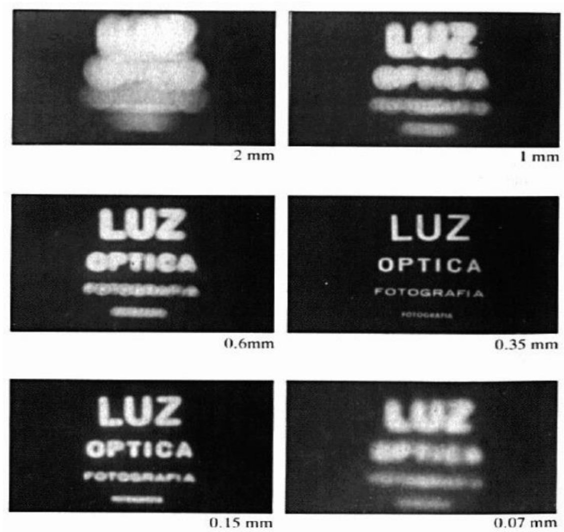
Photograph made with larger pinhole



From *Photography*, London et al.

26

Smaller pinhole is sharper …to a point



Slide after Steve Seitz, U. Washington

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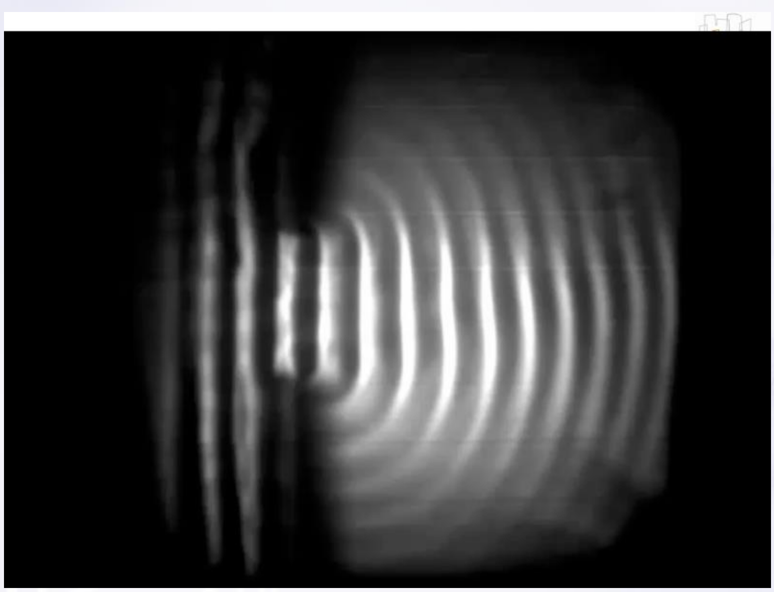
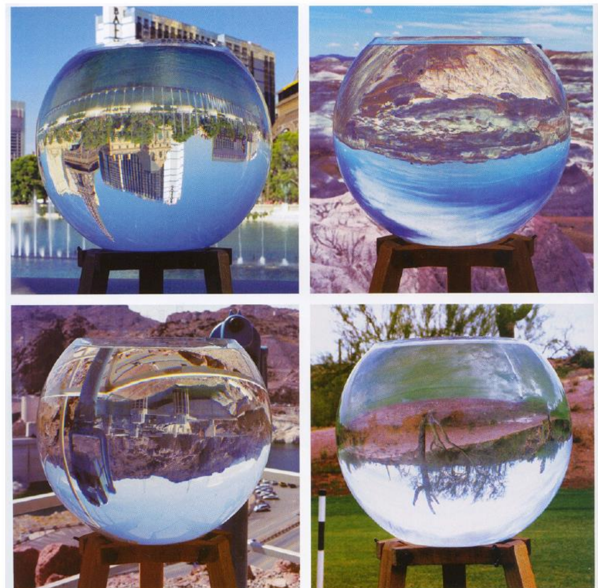
27



28

Replacing pinholes with lenses



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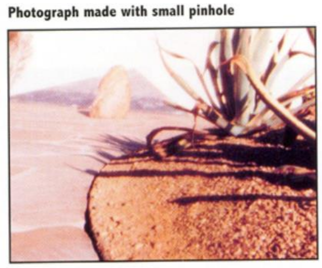
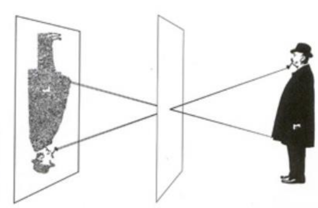
29

Lenses

- **Gather more light!**
- **But need to be focused**

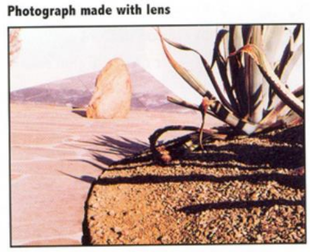
Photograph made with small pinhole

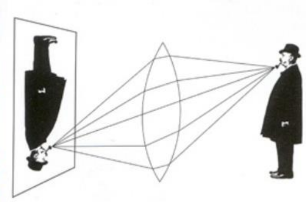




To make this picture, the lens of a camera was replaced with a thin metal disk pierced by a tiny pinhole, *equivalent in size to an aperture of f/182. Only a few rays of light from each point on the subject got through the tiny opening, producing a soft but acceptably clear photograph. Because of the small size of the pinhole, the exposure had to be 6 sec long.*

Photograph made with lens





This time, using a simple convex lens with an f/16 aperture, *the scene appeared sharper than the one taken with the smaller pinhole, and the exposure time was much shorter, only 1/100 sec.*

The lens opening was much bigger than the pinhole, letting in far more light, but it focused the rays from each point on the subject precisely so that they were sharp on the film.

From Photography, London et al.

slide by Frédo Durand, MIT

30

More ingredients

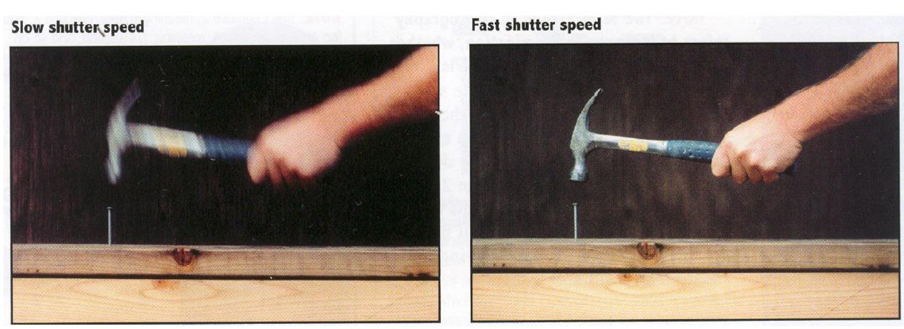
- **Timed shutter**
  with a UI for setting the duration of the exposure ("**exposure time**")
- **Variable aperture**
  effective size of the hole through which light enters can be changed
  with a UI for setting the size ("**aperture**")
- **Viewfinder**
  some way better than guessing
  to tell what you are photographing

photo: Ken Rockwell

Main effect of shutter speed

CSAIL

- **Motion blur**



From Photography, London et al.

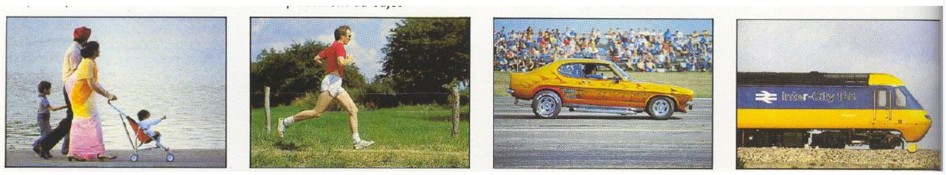
slide by Frédo Durand, MIT

Effect of shutter speed

CSAIL

- **Freezing motion**

Walking people | Running people | Car | Fast train



1/125 | 1/250 | 1/500 | 1/1000

slide by Frédo Durand, MIT

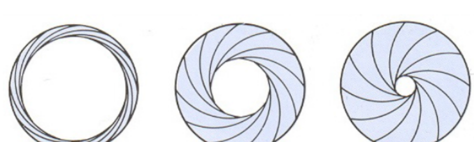
Note: it doesn't mean that shutter speed is proportional to the absolute speed of the object. Object distance is very important, and a photographer often tracks the subject.

33

Aperture

CSAIL

- **Diameter of the lens opening (controlled by diaphragm)**
- **Expressed as a fraction of focal length, in f-number**
  - f/2.0 on a 50mm means that the aperture is 25mm
  - f/2.0 on a 100mm means that the aperture is 50mm



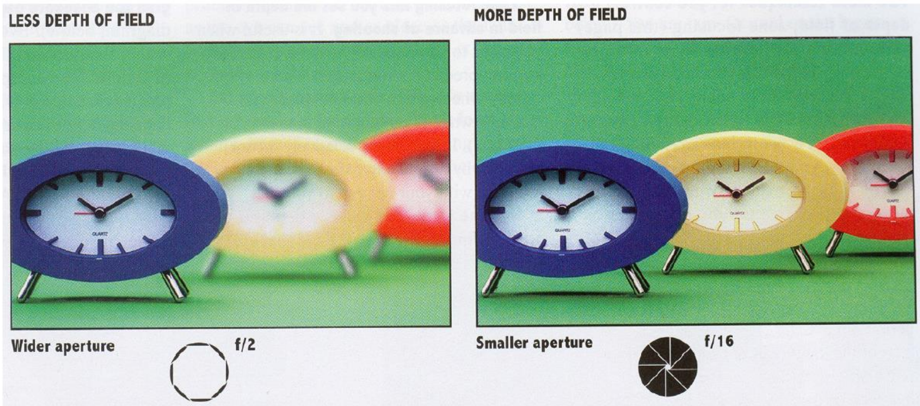
Full aperture | Medium aperture | Stopped down

Worth a look:
www.youtube.com/watch?v=KmNIouLByJQ

slide by Frédo Durand, MIT

34

Depth of field



From Photography, London et al.

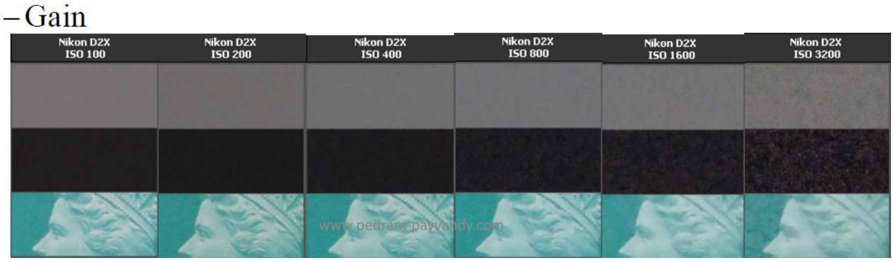
slide by Frédo Durand, MIT

35

Sensitivity (ISO)

- Third variable for exposure
- Linear effect (200 ISO needs half the light as 100 ISO)
- Film photography: trade sensitivity for grain

- Digital photography: trade sensitivity for noise
  - Gain



From dpreview.com

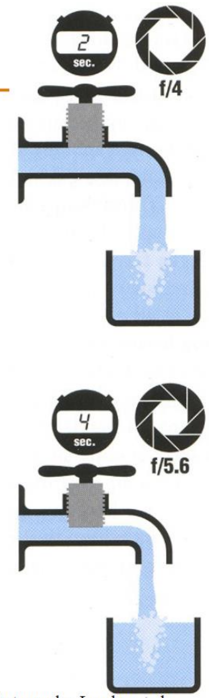
slide by Frédo Durand, MIT

36

Exposure

- **Two main parameters:**
  - –Aperture (in f stop)
  - –Shutter speed (in fraction of a second)
- **Reciprocity**

  The same exposure is obtained with an exposure twice as long and an aperture *area* half as big



From Photography, London et al.

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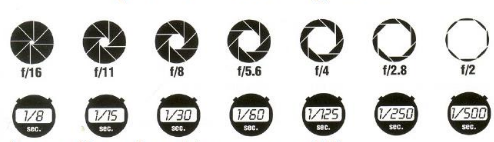
37

Reciprocity

- **Assume we know how much light we need**
- **We have the choice of an infinity of shutter speed/ aperture pairs**



- **What will guide our choice of a shutter speed?**
  - –Freeze motion vs. motion blur, camera shake
- **What will guide our choice of an aperture?**
  - –Depth of field, diffraction limit
- **Often we must compromise**
  - –Open more to enable faster speed (but shallow DoF)

slide by Frédo Durand, MIT

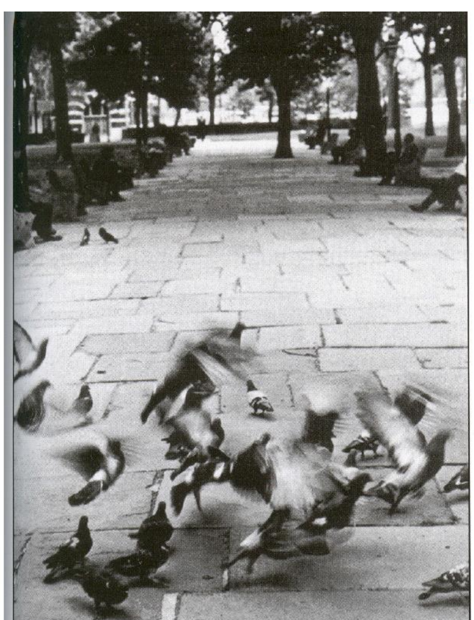
38

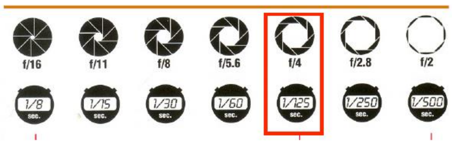
Small aperture (deep depth of field), slow shutter speed (motion blurred). *In th[is] scene, a small aperture (f/16) produced great depth of field; the nearest paving stones as well as the farthest trees are sharp. But to admit enough light, a slow shutter speed (1/8 sec) was needed; it was too slow to show moving pigeons ... It also meant that a tripod had to be used to hold the camera steady.*

From Photography, London et al.

slide by Frédo Durand, MIT

39



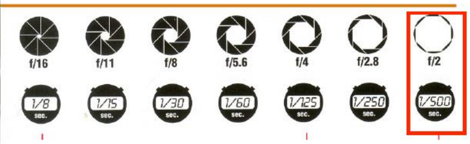


Medium aperture (moderate depth of field), medium shutter speed (some motion sharp). *A medium aperture (f/4) and shutter speed (1/125 sec) sacrifice some background detail to produce recognizable images of the birds. But the exposure is still too long to show the motion of the birds' wings sharply.*

From Photography, London et al.

slide by Frédo Durand, MIT

40



CSAIL

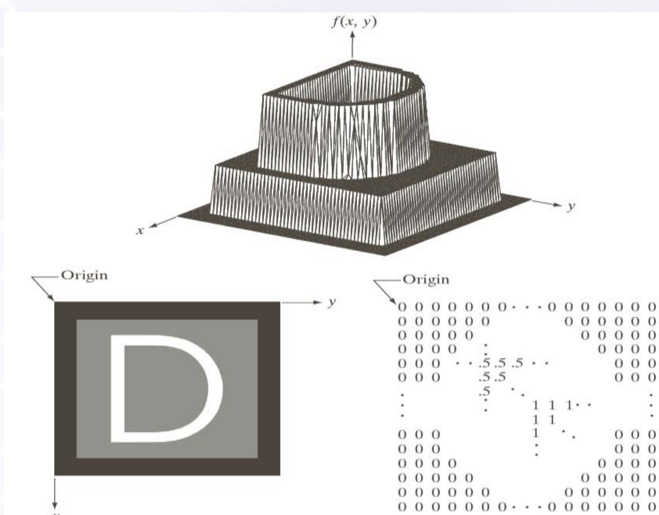
Large aperture (shallow depth of field), fast shutter speed (motion sharp). *A fa shutter speed (1/500 sec) stops the motion of the pigeons so completely that the flapping wings are frozen. But the wide aperture (f/2) needed gives so little dept of field that the background is now out of focus.*

From Photography, London et al.

slide by Frédo Durand, MIT

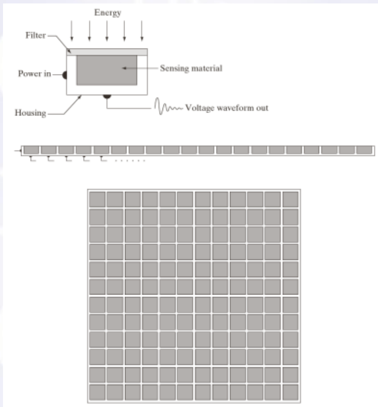
41

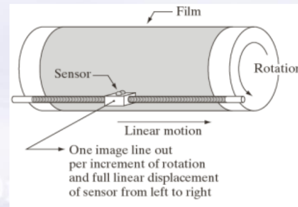
نمایش تصویر دیجیتال

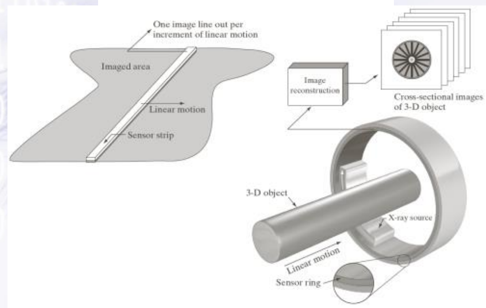


42

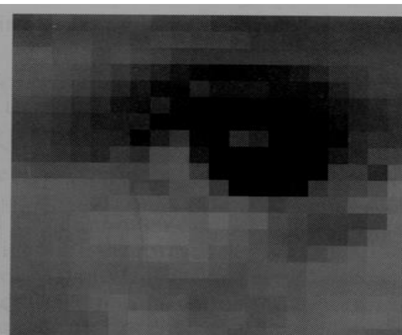
تصویر برداری با حسگر





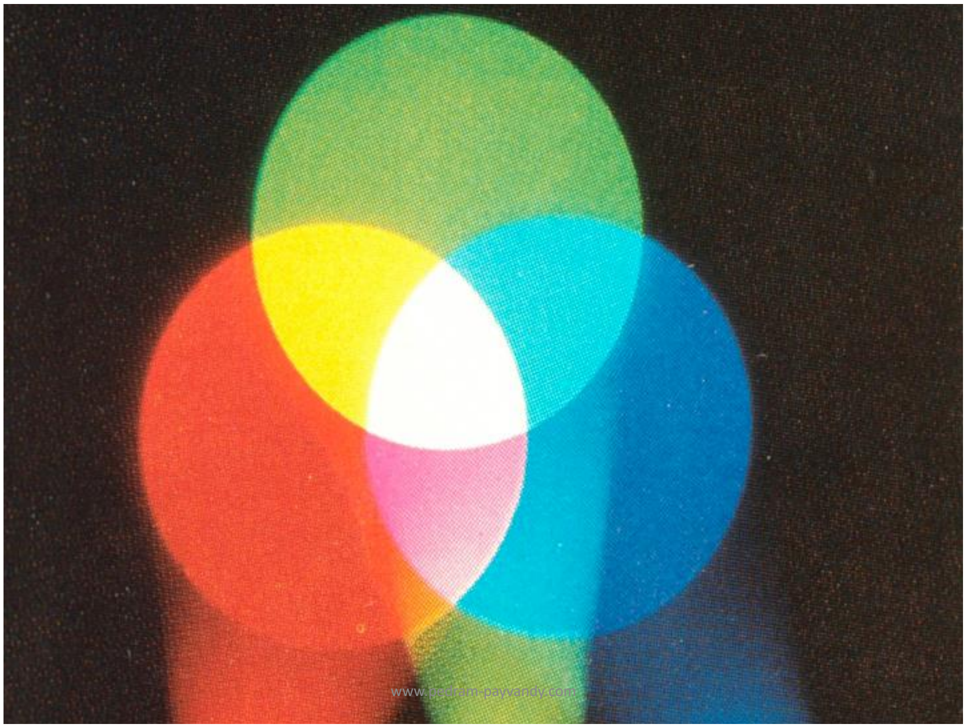


43

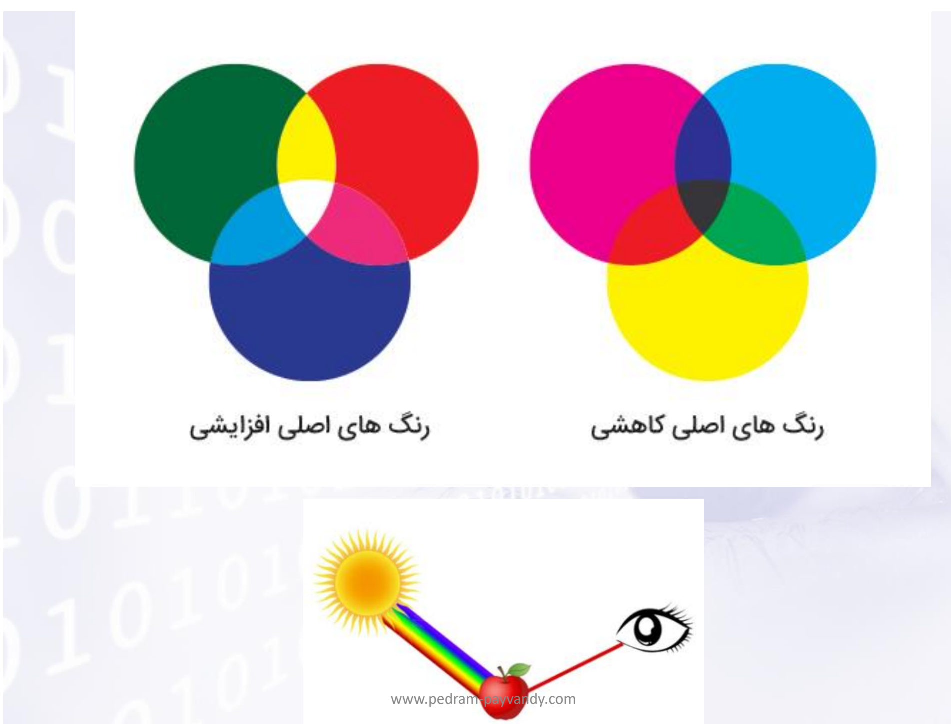


117	125	133	127	130	130	133	121	116	115	100	91	93	94	99	103	112	105	109	106
134	133	138	138	132	134	130	133	128	123	121	113	106	102	99	106	113	109	109	113
146	147	138	140	125	134	124	115	102	96	93	94	99	96	99	100	103	110	109	110
144	141	136	130	120	108	88	74	53	37	31	37	35	39	53	79	93	100	109	116
139	136	129	119	102	85	58	31	41	77	51	53	53	33	37	41	69	94	105	108
132	127	117	102	87	57	49	77	42	28	17	15	13	13	17	41	53	69	88	100
124	120	108	94	72	74	72	31	35	31	15	13	15	11	15	13	46	75	83	96
125	115	102	93	88	82	42	79	113	41	19	100	82	11	11	17	31	91	99	100
124	116	109	99	91	113	99	140	144	57	20	20	15	11	15	17	63	87	119	124
136	133	133	135	138	133	132	144	150	120	24	17	15	15	17	20	115	113	88	150
158	157	157	154	149	145	133	127	146	150	116	35	20	19	28	105	124	128	141	171
155	154	156	155	146	155	154	154	147	139	148	150	138	120	128	129	130	151	156	165
150	151	154	162	166	167	169	174	172	167	177	166	164	140	134	120	121	120	127	172
145	149	151	157	165	169	173	179	176	166	166	157	145	136	129	124	120	136	163	168
144	148	153	160	159	158	165	172	165	169	157	151	149	141	130	140	151	162	169	167
144	141	147	155	154	149	156	151	157	157	151	144	147	147	149	159	158	159	166	165
139	140	140	150	153	151	150	146	140	139	138	140	145	151	149	156	156	162	162	161
136	134	138	146	156	164	153	146	145	136	139	139	140	141	149	157	159	161	169	166
136	133	136	135	144	159	168	159	151	142	141	145	139	146	153	156	164	167	172	168
133	129	140	142	146	159	167	165	154	151	146	141	147	154	156	160	161	157	153	154

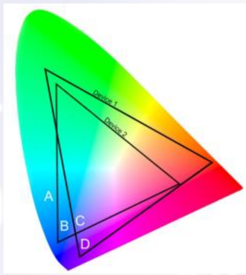
44

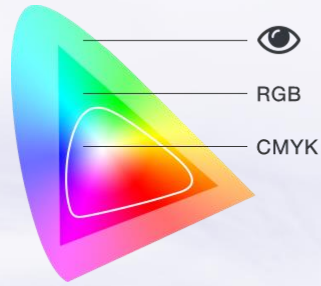

www.pedram-payvandy.com

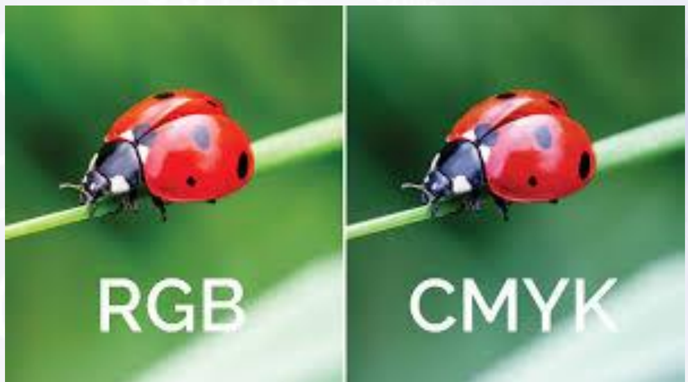
45


رنگ های اصلی افزایشی
رنگ های اصلی کاهشی
www.pedram-payvandy.com

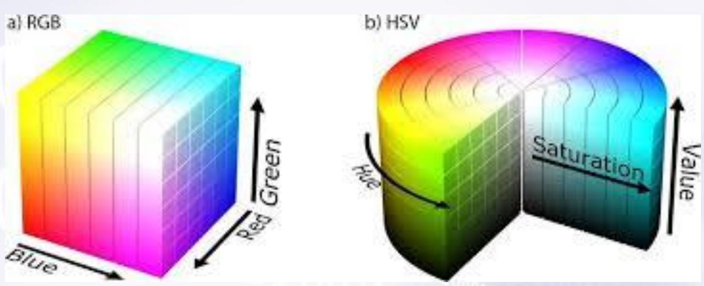
46

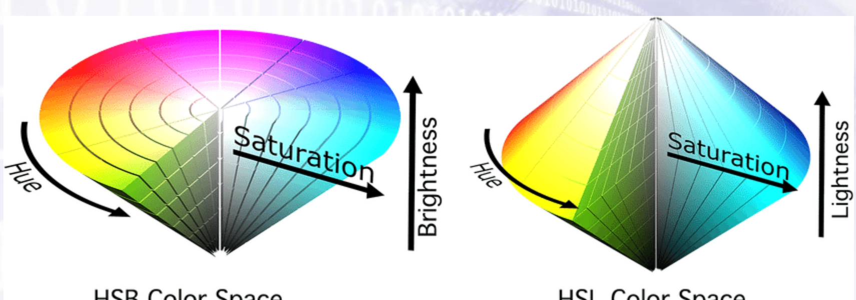

A
B
C
D


RGB
CMYK

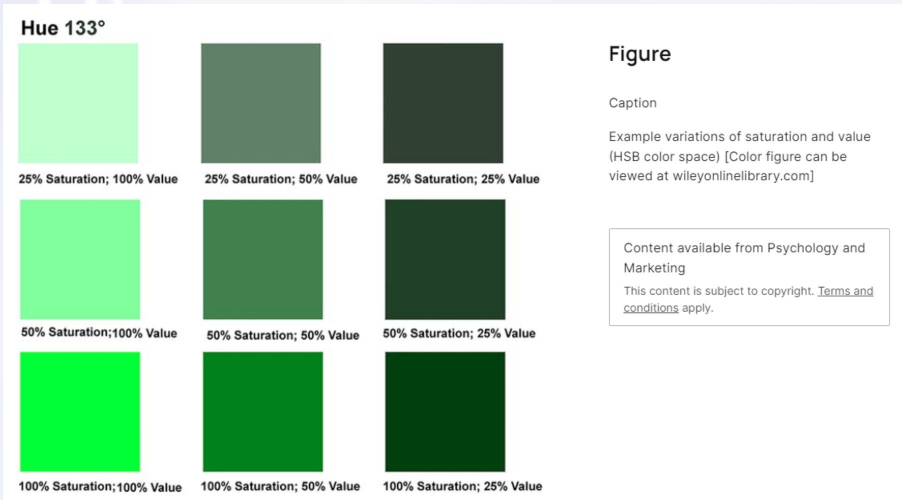

RGB
CMYK

47


a) RGB
Blue
Red
Green
b) HSV
Hue
Saturation
Value


Hue
Saturation
Brightness
HSB Color Space
Hue
Saturation
Lightness
HSL Color Space

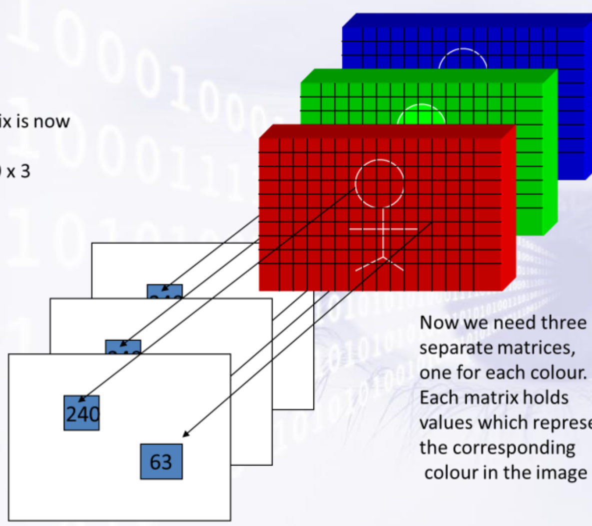
48



49

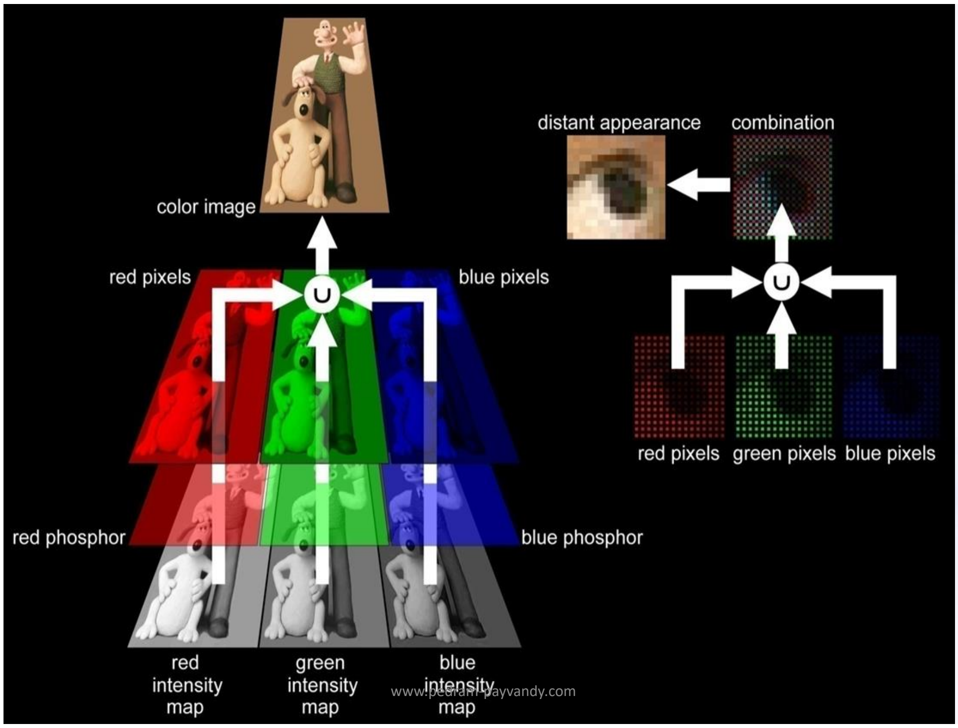
نمایش تصویر دیجیتال

Our matrix is now
Of size
640 x 480 x 3



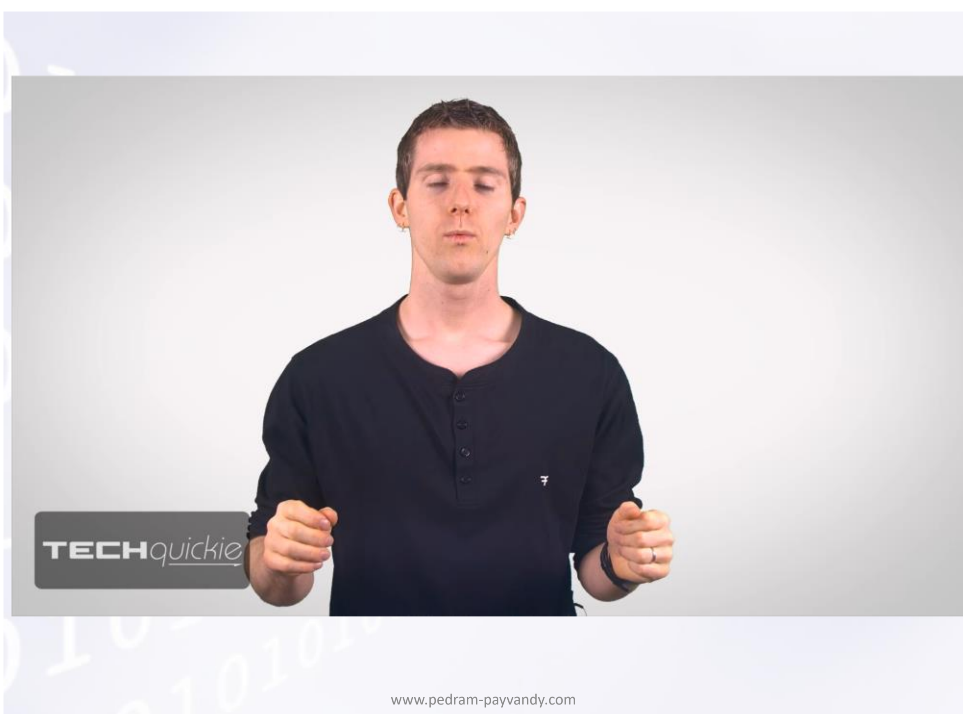
Now we need three separate matrices, one for each colour. Each matrix holds values which represent the corresponding colour in the image

50



distant appearance
combination
color image
red pixels
blue pixels
red pixels green pixels blue pixels
red phosphor
blue phosphor
red intensity map
green intensity map
blue intensity map
www.pedram-payvandy.com

51



TECHquickie
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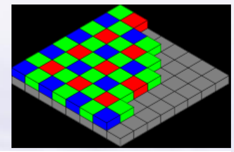
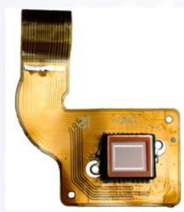
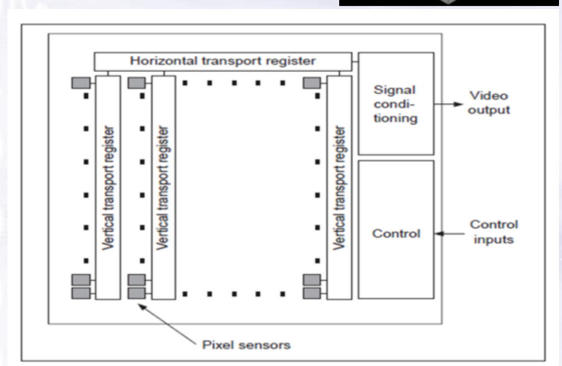
52

تصویر برداری با حسگر

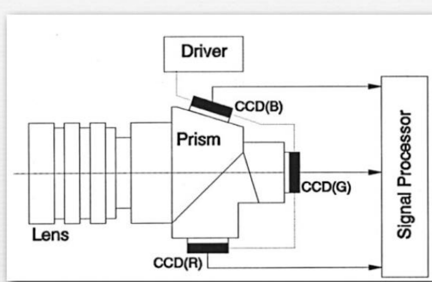






53

3-chip cameras



(Theuwissen)

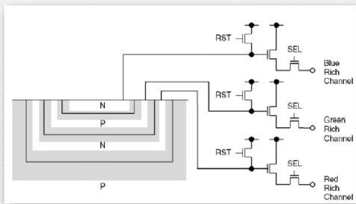
- high-quality video cameras
- prism & dichroic mirrors split the image into 3 colors, each routed to a separate sensor (typically CCD)
- no light loss, as compared to filters (which absorb light)
- expensive, and complicates lens design

slide by Marc Levoy, Stanford

22

54

Foveon stacked sensor



- longer wavelengths penetrate deeper into silicon, so arrange a set of vertically stacked detectors
  - top gets mostly blue, middle gets green, bottom gets red
  - no control over spectral responses, so requires processing
- fewer moiré artifacts than color filter arrays + demosaicing
  - but possibly worse noise performance, especially in blue

slide by Marc Levoy, Stanford

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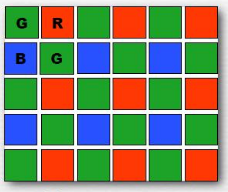
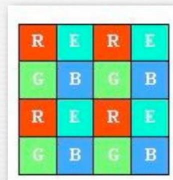
55

56

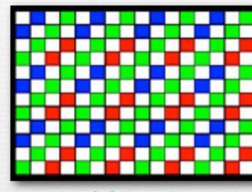
Color filter arrays



Bayer pattern



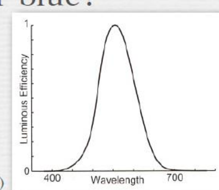
Sony RGB+E
better color



Kodak RGB+C
more dynamic range

- Why more green pixels than red or blue?
  - because green pixels come closest to measuring luminance
  - human eye cares mostly about detailed luminance, not so much for chromaticity

(Stone)



24

57

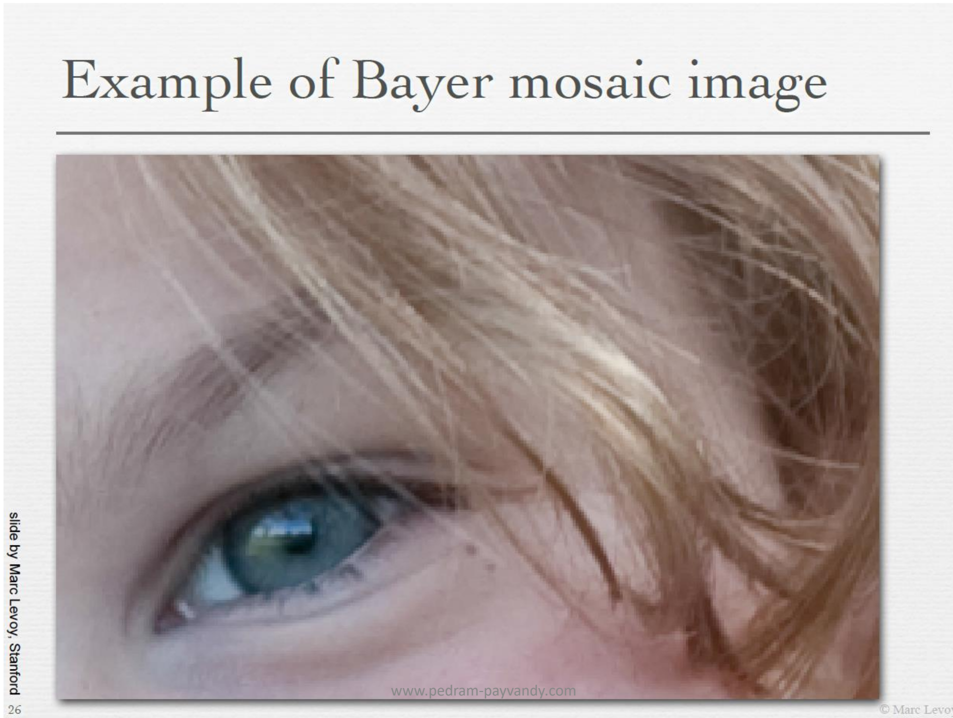
Example of Bayer mosaic image

Small fan at Stanford women's soccer game

(Canon 1D III)

25

58


Example of Bayer mosaic image
slide by Marc Levoy, Stanford
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© Marc Levoy

59


Before demosaicing (dcraw -d)
slide by Marc Levoy, Stanford
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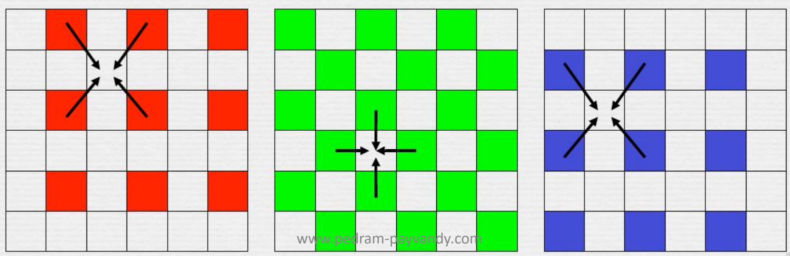
60

Demosaicing

- linear interpolation
  - average of the 4 nearest neighbors of the same color
- cameras typically use more complicated scheme
  - try to avoid interpolating across contrasty edges
  - demosaicing is often combined with denoising, sharpening...
- due to demosaicing, 2/3 of your data is "made up"!



slide by Marc Levoy, Stanford

28

61

تصویر برداری با آرایه های حسگر

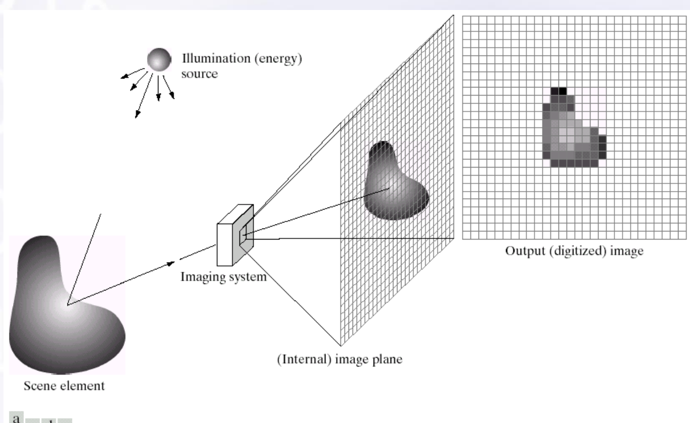
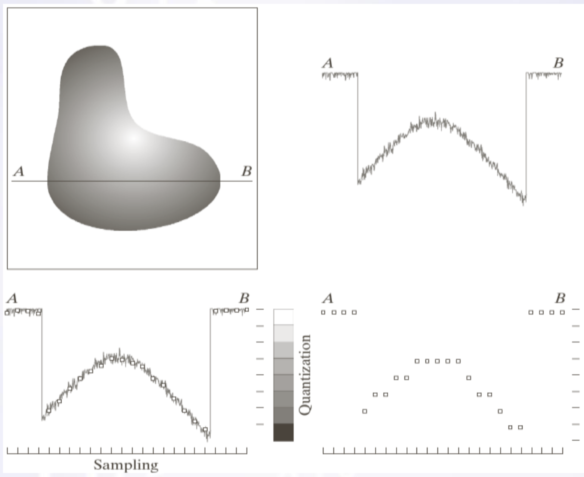


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

62

نمونه برداری –کمی سازی

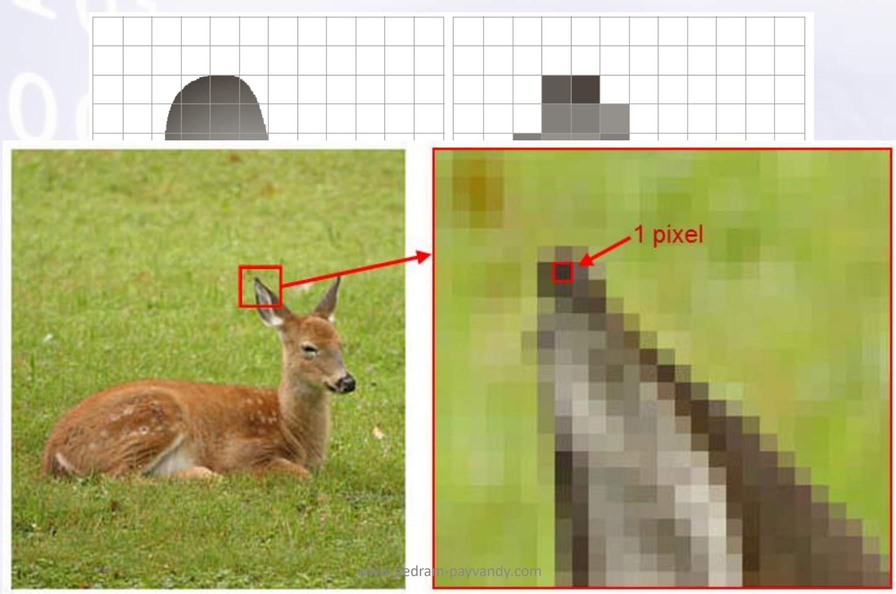


دیجیتال کردن مقادیر را نمونه برداری گویند

دیجیتال کردن دامنه را کمی سازی گویند

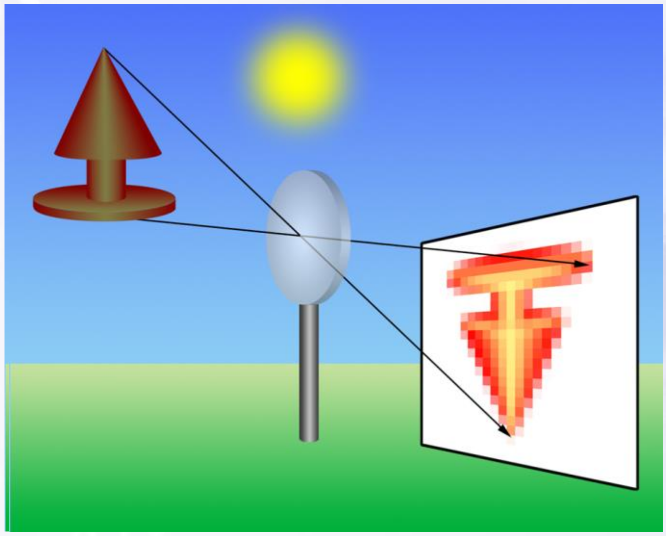
63

نمونه برداری –کمی سازی



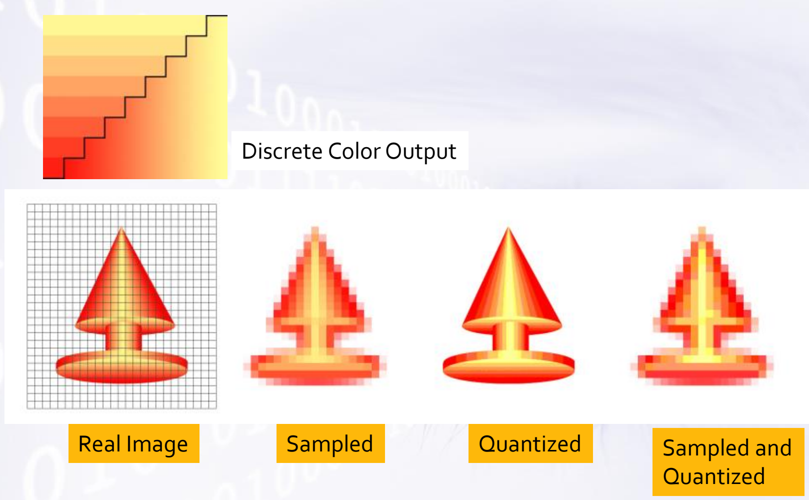
64

نمونه برداری –کمی سازی



65

نمونه برداری –کمی سازی



66

نمایش تصویر دیجیتال

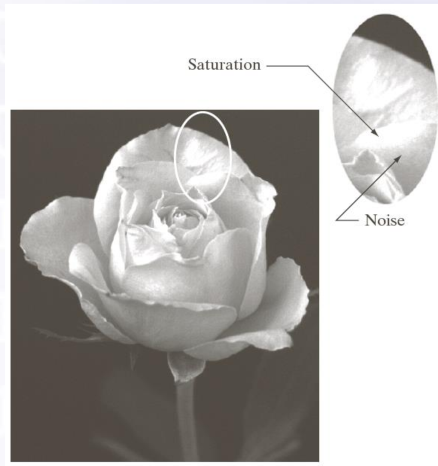


FIGURE 2.19 An image exhibiting saturation and noise. Saturation is the highest value beyond which all intensity levels are clipped (note how the entire saturated area has a high, *constant* intensity level). Noise in this case appears as a grainy texture pattern. Noise, especially in the darker regions of an image (e.g., the stem of the rose) masks the lowest detectable true intensity level.

67

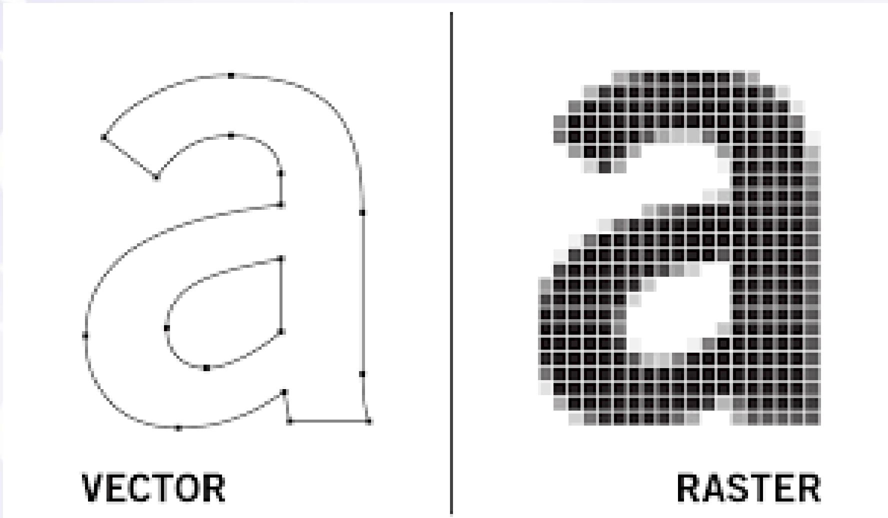
ذخیره سازی تصویر دیجیتال

128×128 with 64 gray levels ⇨ 98,304bits=128KB

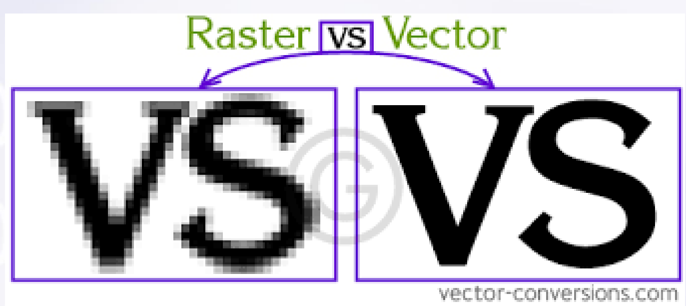
TABLE 2.1
Number of storage bits for various values of N and k.

N/k	1 (L = 2)	2 (L = 4)	3 (L = 8)	4 (L = 16)	5 (L = 32)	6 (L = 64)	7 (L = 128)	8 (L = 256)
32	1,024	2,048	3,072	4,096	5,120	6,144	7,168	8,192
64	4,096	8,192	12,288	16,384	20,480	24,576	28,672	32,768
128	16,384	32,768	49,152	65,536	81,920	98,304	114,688	131,072
256	65,536	131,072	196,608	262,144	327,680	393,216	458,752	524,288
512	262,144	524,288	786,432	1,048,576	1,310,720	1,572,864	1,835,008	2,097,152
1024	1,048,576	2,097,152	3,145,728	4,194,304	5,242,880	6,291,456	7,340,032	8,388,608
2048	4,194,304	8,388,608	12,582,912	16,777,216	20,971,520	25,165,824	29,369,128	33,554,432
4096	16,777,216	33,554,432	50,331,648	67,108,864	83,886,080	100,663,296	117,440,512	134,217,728
8192	67,108,864	134,217,728	201,326,592	268,435,456	335,544,320	402,653,184	469,762,048	536,870,912

68

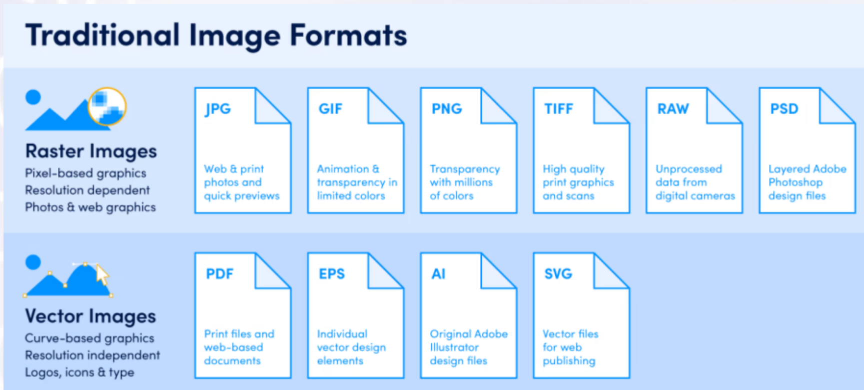

VECTOR
RASTER

69


Raster VS Vector
VS
VS
vector-conversions.com


RASTER
VS
VECTOR
INKABLE

70



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71

Type	Name	Indexed?	Compressed?	Lossy?	Transparency?	Use for	Avoid for	Comments
JPG	Joint Photographic Group	No	Yes	Yes	No	When small file size is more important than quality	Text, line art, and other two-tone images	Variable fidelity can be useful
TIF	Tagged image format	No	Optional	No	Yes	When file size is not an issue	When it is!	Widely used for georeferenced images
PNG	Portable network graphics	No	Usually	No	Yes	Almost anything	When you need small files	Best all-rounder
PGM	Portable gray map	No	No	No	No	Playing with data	General use	Part of the Netpbm family, plain text file is good for scripting
GIF	Graphic image format	Yes	Yes	No	Yes	Animations	Photographs	Multiple layers interpreted as animation; doesn't scale
BMP	Windows bitmap	No	No	No	No	Nothing	Always avoid it	Esoteric and uncompressed, it has little going for it

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72

دقت شدت و دقت فضایی

دقت فضایی معیاری از کوچکترین بخش قابل تشخیص در تصویراست

دقت شدت کوچکترین تغییر قابل تشخیص در سطح شدت است

73

دقت شدت و دقت فضایی

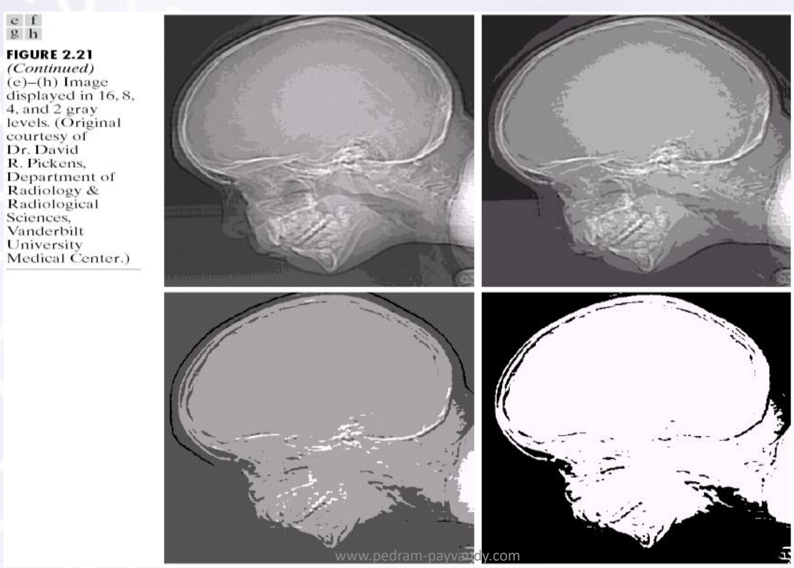

FIGURE 2.21 *(Continued)* (e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)

74

رابطه دقت شدت و دقت فضایی

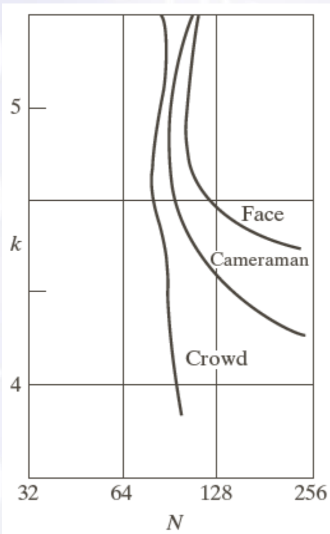

FIGURE 2.23 Typical isopreference curves for the three types of images in Fig. 2.22.

FIGURE 2.22 (a) Image with a low level of detail. (b) Image with a medium level of detail. (c) Image with a relatively large amount of detail. (Image (b) courtesy of the Massachusetts Institute of Technology.)

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75

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76