

اصول پردازش تصویر

Principles of Image Processing

مصطفی کمالی تبریزی
۳۱ شهریور ۱۳۹۹
جلسه دوم

Basics of Image Processing

What is an image?



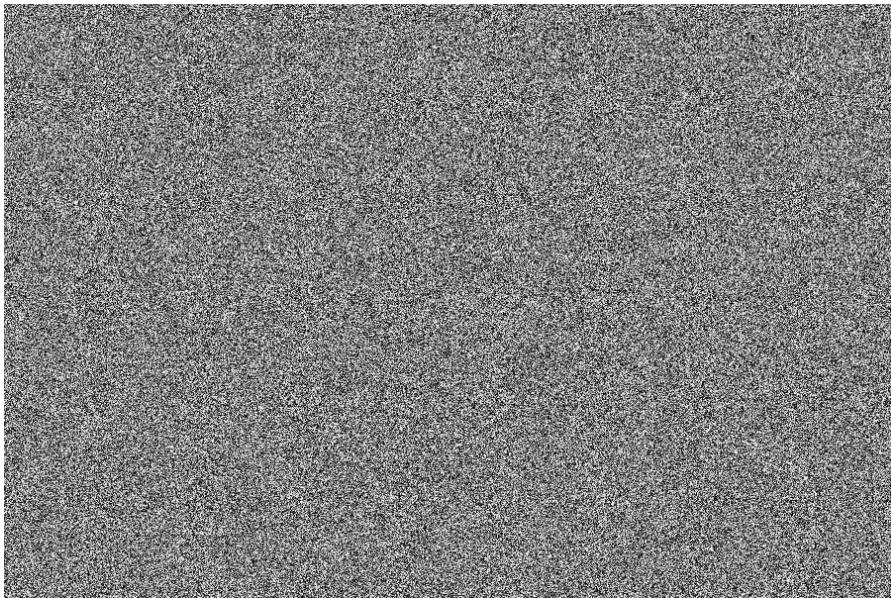
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Grayscale image = $m \times n$ matrix

600×900

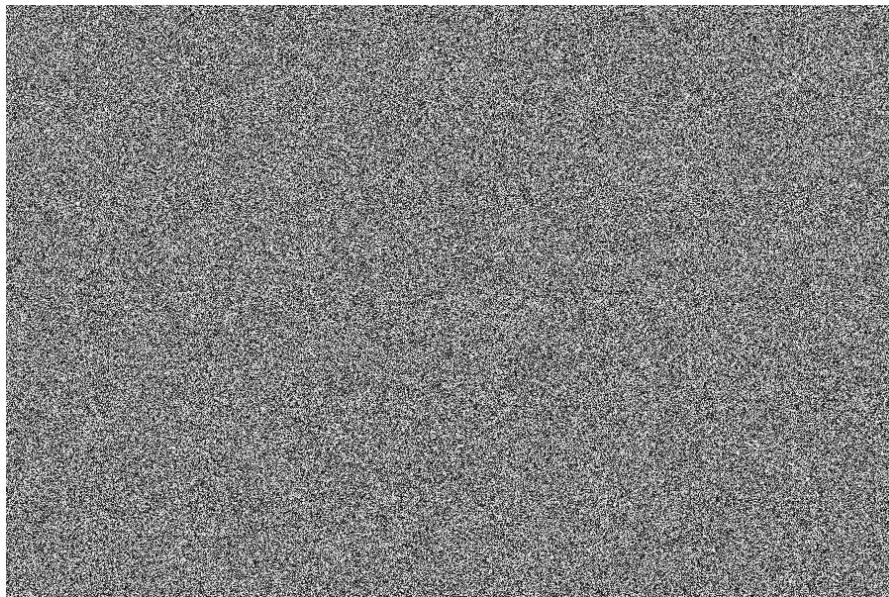


4×3

209	59	120
41	179	153
186	247	232
224	148	179

Grayscale image = $m \times n$ matrix

600×900



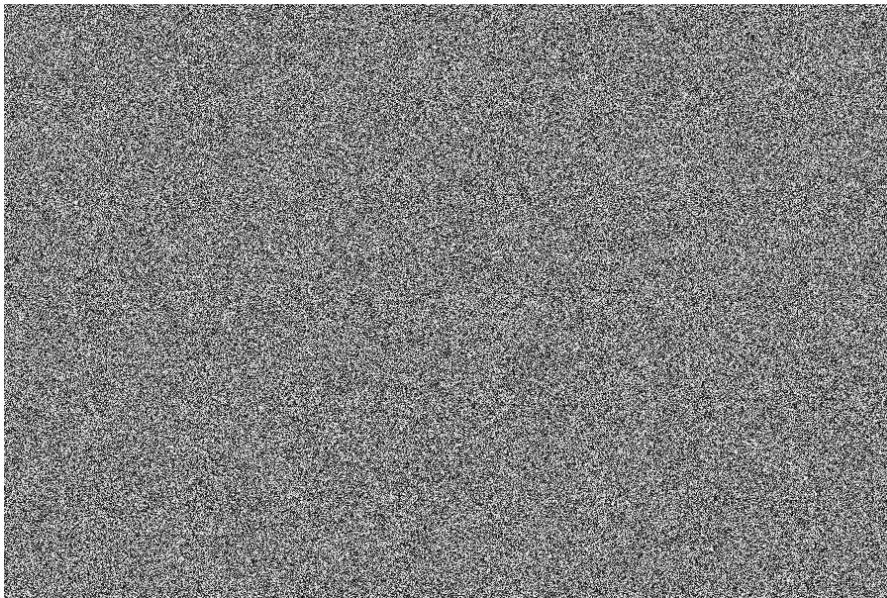
4×3

209	59	120
41	179	153
186	247	232
224	148	179

pixel = picture element

Grayscale image = $m \times n$ matrix

600×900



4×3

209	59	120
41	179	153
186	247	232
224	148	179

pixel = picture element

grayscale spectrum



$$255 = 2^8 - 1 \rightarrow 8 \text{ bits} = 1 \text{ byte}$$

Why not 16 bits or 4 bits?

8-bit



4-bit



$m \times n$ image $\rightarrow mn$ pixels

SAMSUNG Galaxy
S9 rear camera

image size: $3,024 \times 4,032$

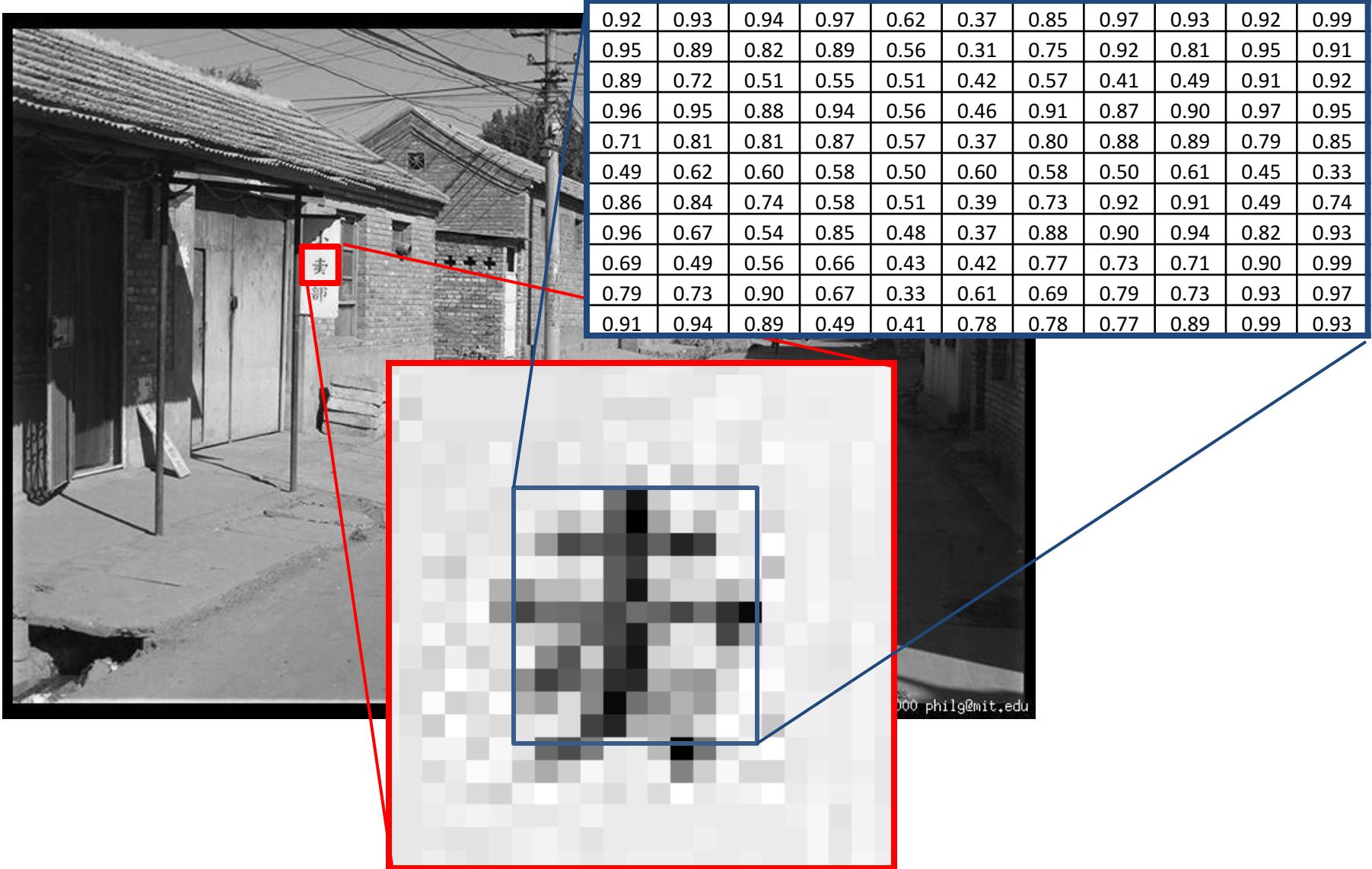


pixels = 12,192,768

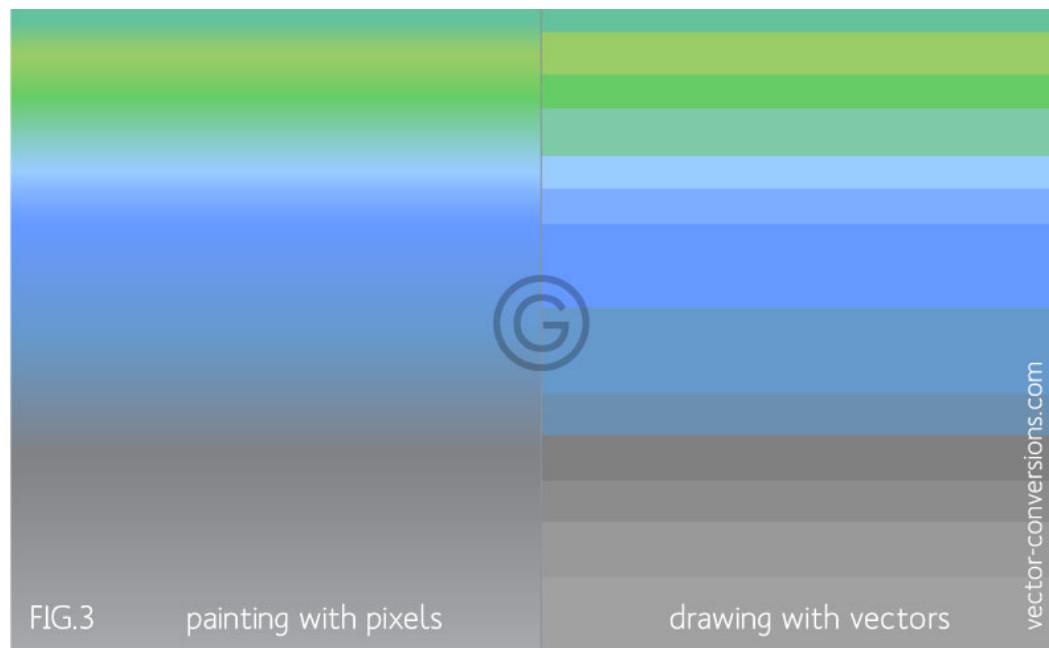
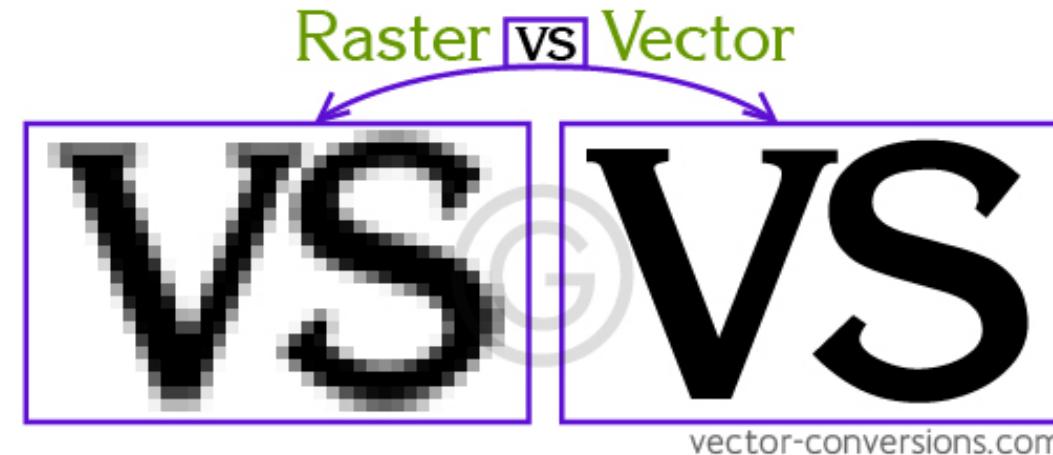


raw size ≈ 12 MB

The raster image (pixel matrix)

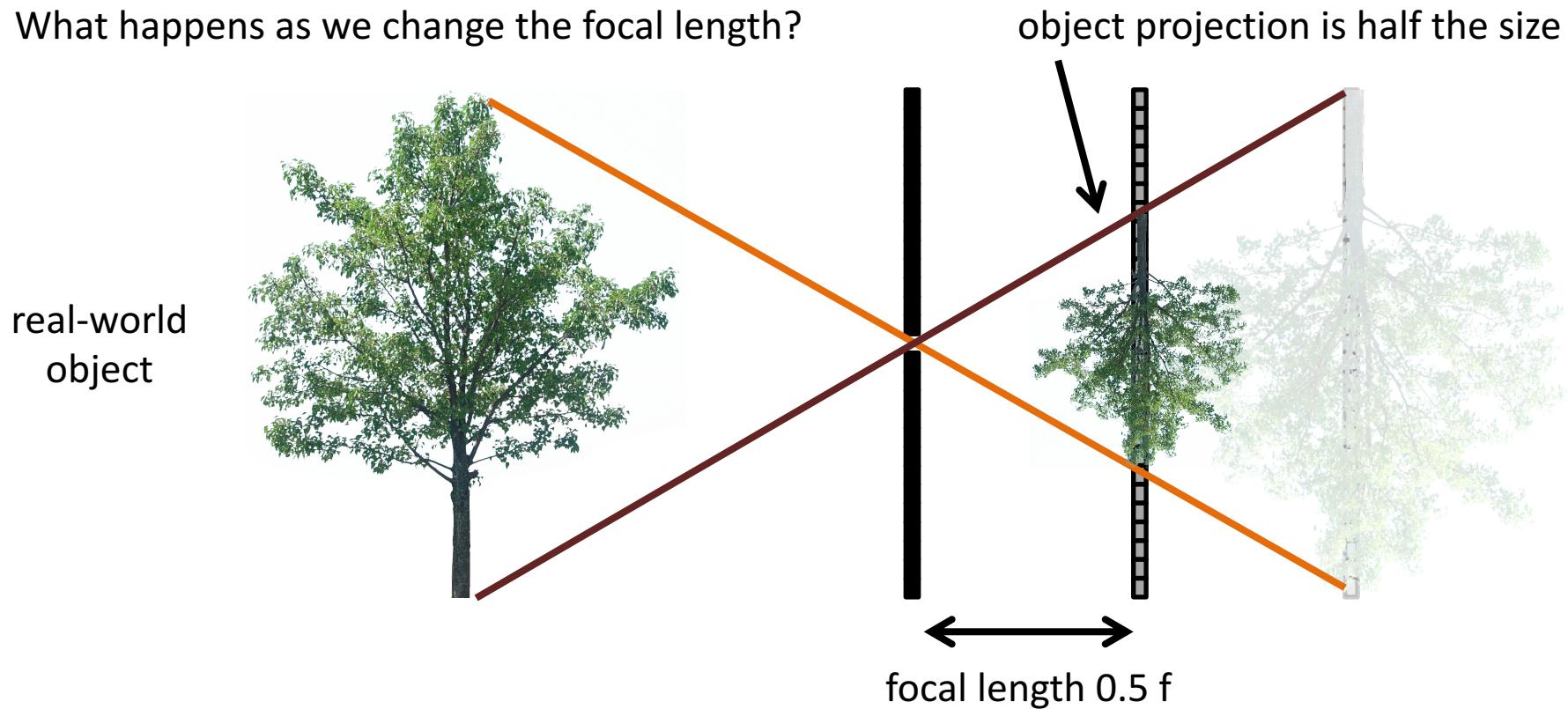


Raster Images vs Vector Images



Pinhole imaging

What happens as we change the focal length?



Digital camera



A digital camera replaces film with a sensor array

- Each cell in the array is light-sensitive diode that converts photons to electrons
- Two common types:
 - Charge Coupled Device (CCD): larger yet slower, better quality
 - Complementary Metal Oxide Semiconductor (CMOS): high bandwidth, lower quality
- <http://electronics.howstuffworks.com/digital-camera.htm>

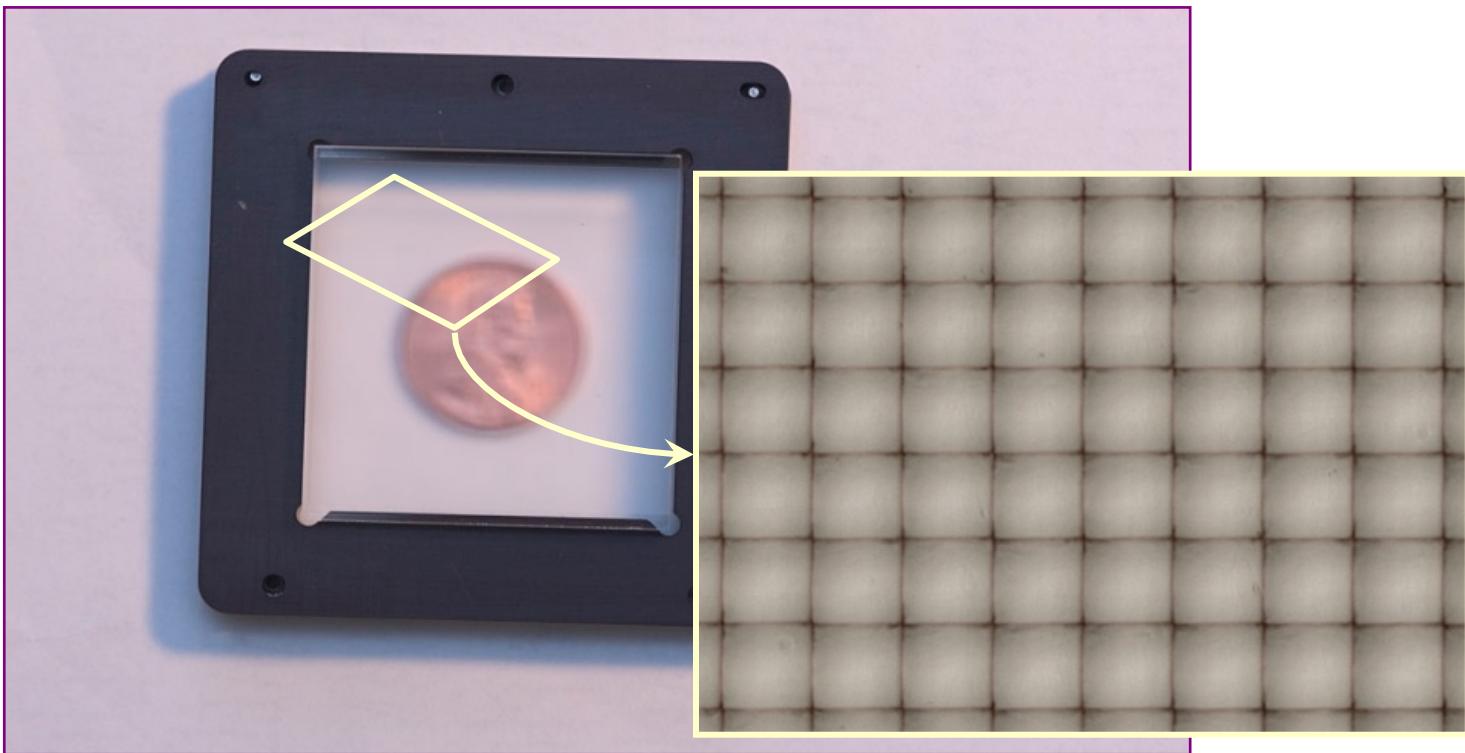
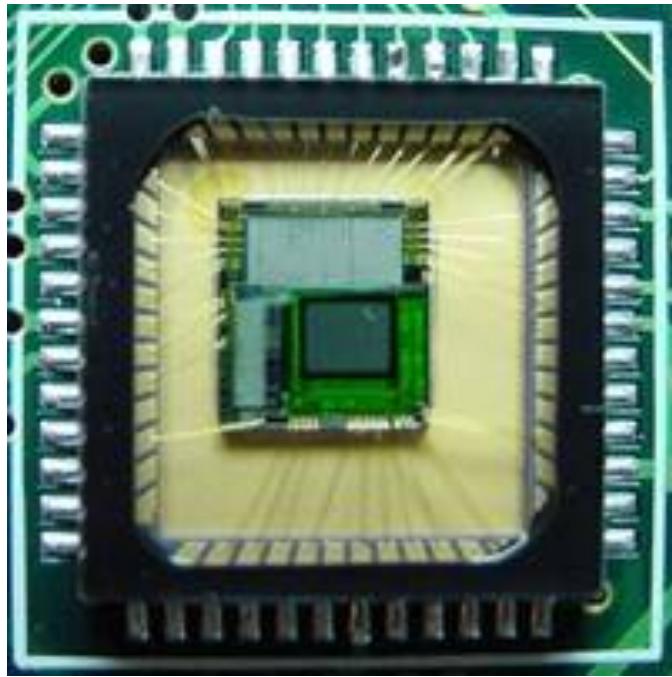


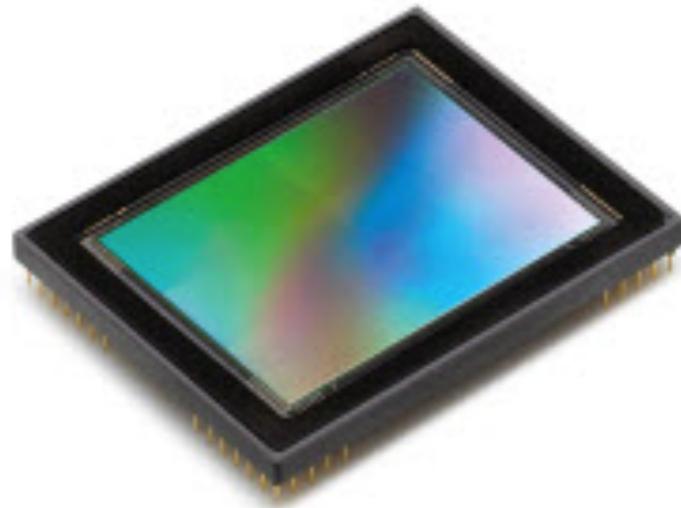
Photo Credit: Rob Fergus

SAMSUNG Galaxy
S9 rear camera → $\left\{ \begin{array}{l} \textit{resolution}: 3,024 \times 4,032 \\ \textit{sensor size}: 4.23 \times 5.64 \text{ mm} \\ \textit{pixel size}: 1.4 \mu\text{m} \end{array} \right.$

Camera Sensors



CMOS sensor
Mostly Rolling Shutter
Cheap & compact

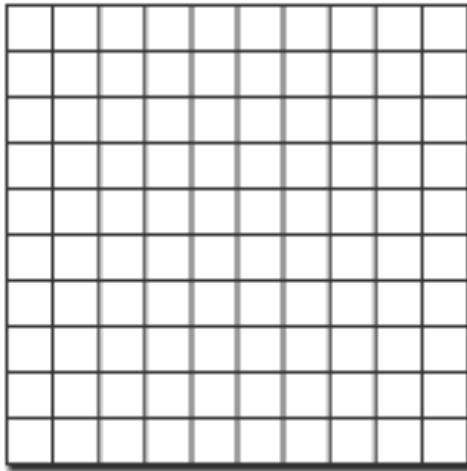


CCD sensor
Mostly Global Shutter
Better Quality

For interested people: [AIA - Camera and Image Sensor Technology Fundamentals](#)

Camera Shutters

Rolling Shutter



Total Shutter

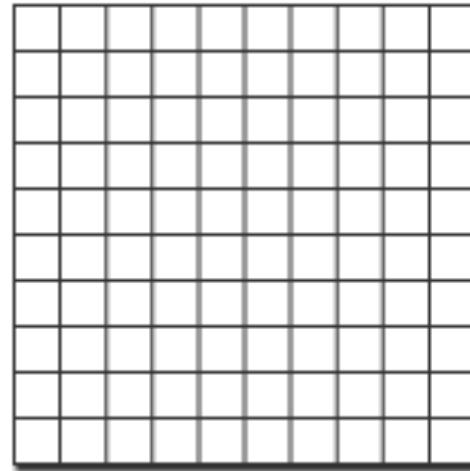


Photo from <https://www.premiumbeat.com/>

Global shutter

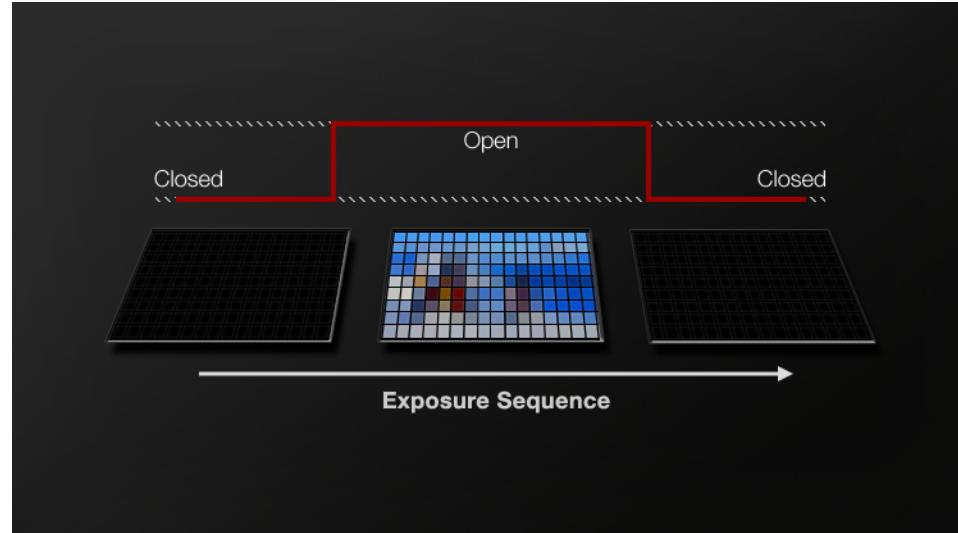


Photo from <https://www.premiumbeat.com/>

Rolling Shutter

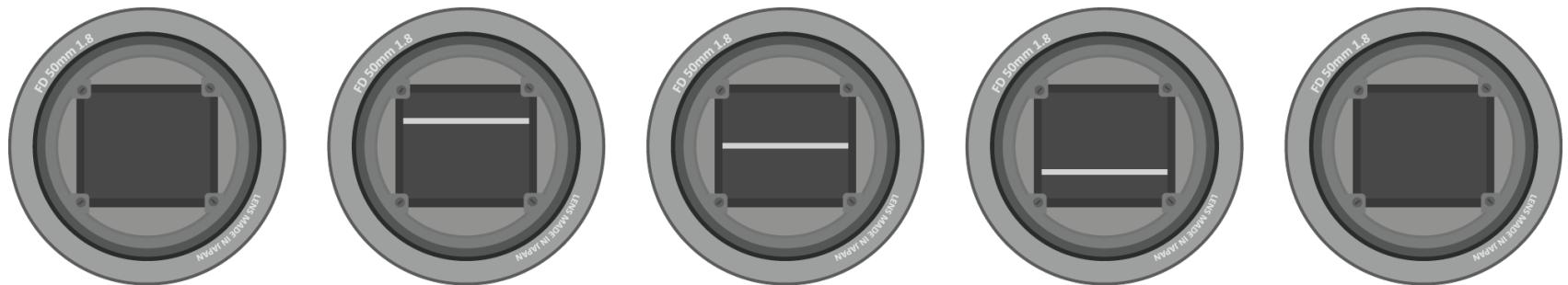


Photo from <https://www.bhphotovideo.com/>

Rolling Shutter Effect



Photo from <https://www.bhphotovideo.com/>

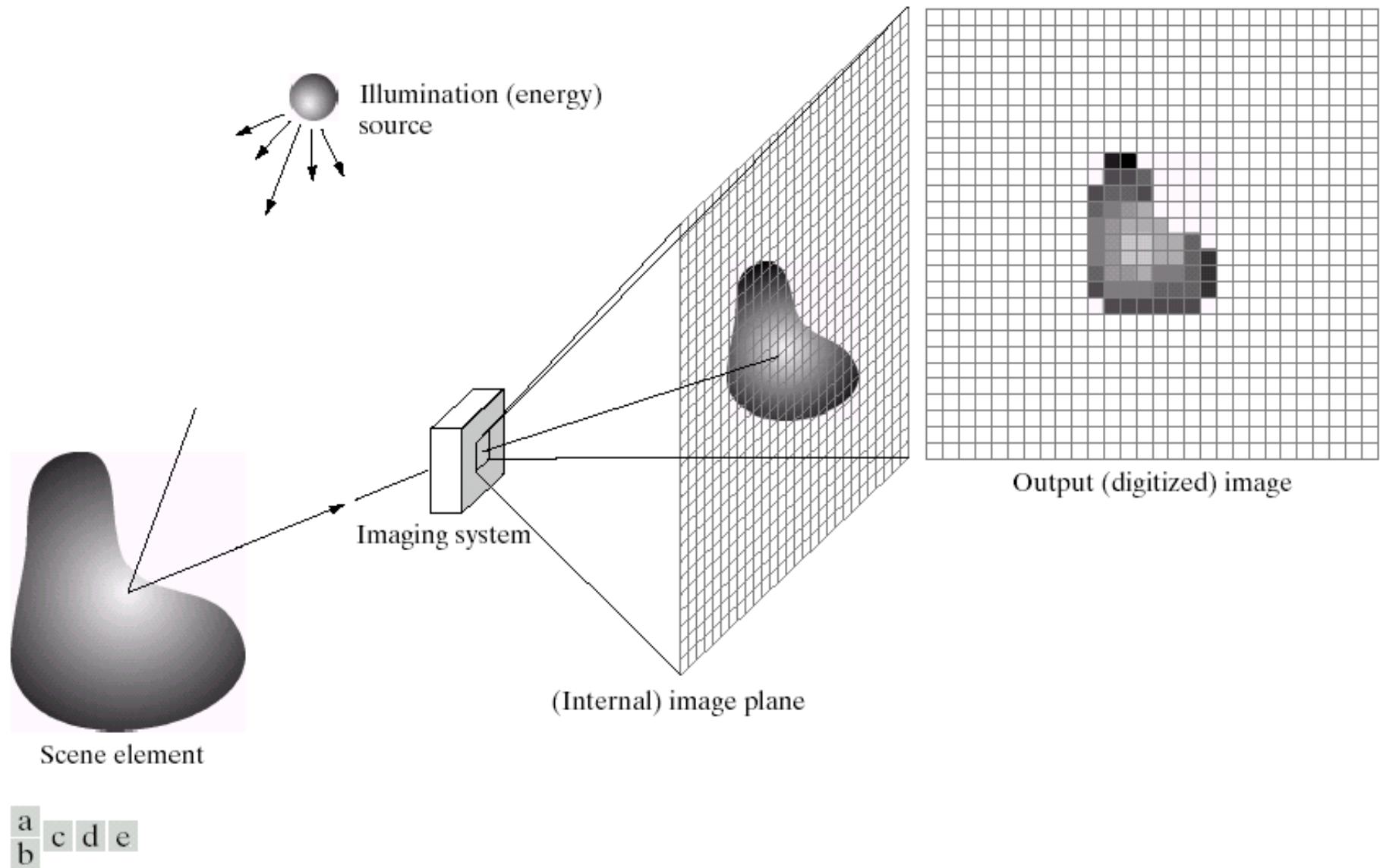
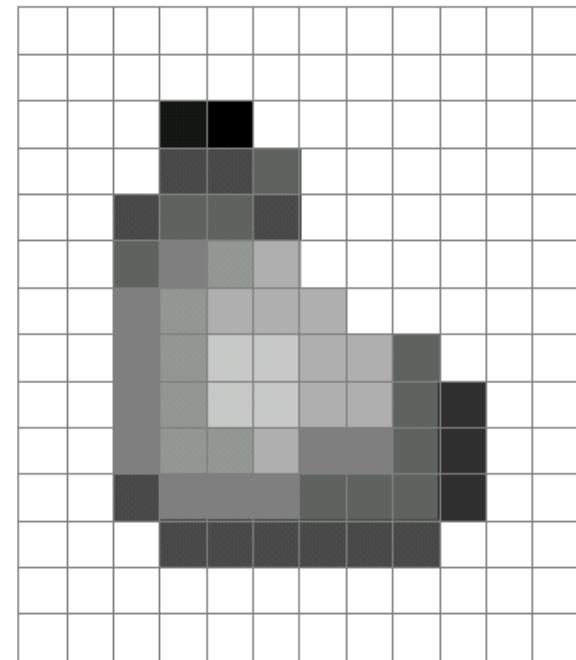
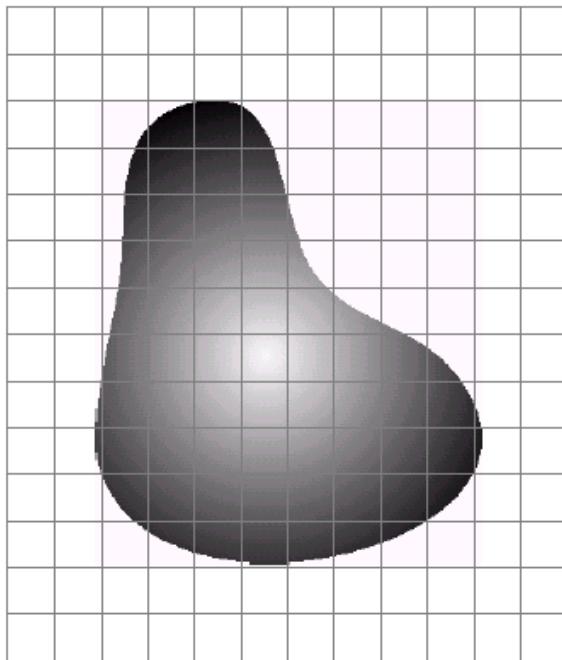


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy (“illumination”) source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

Image Formation

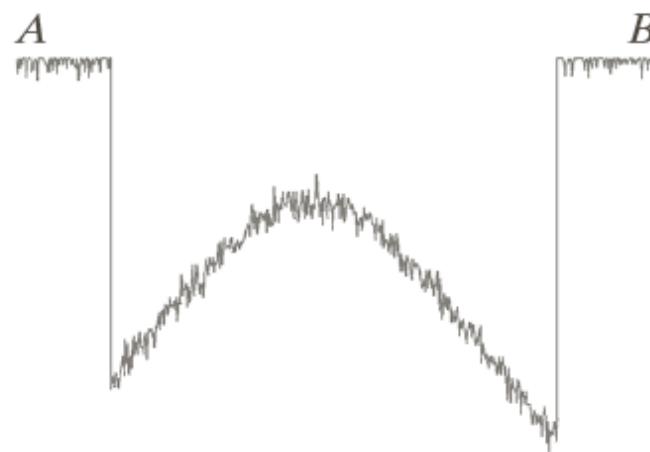
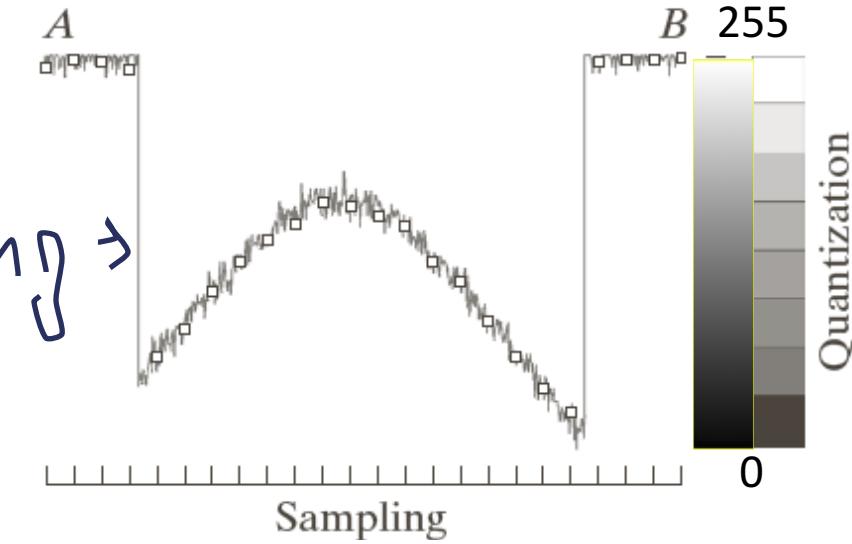
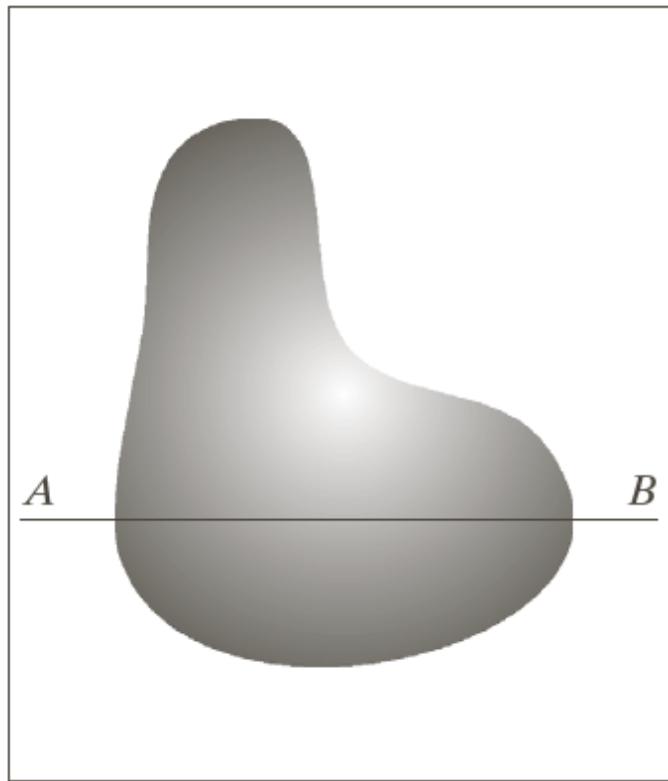


→ سیاه = ۰

← سفید = ۲۵۵

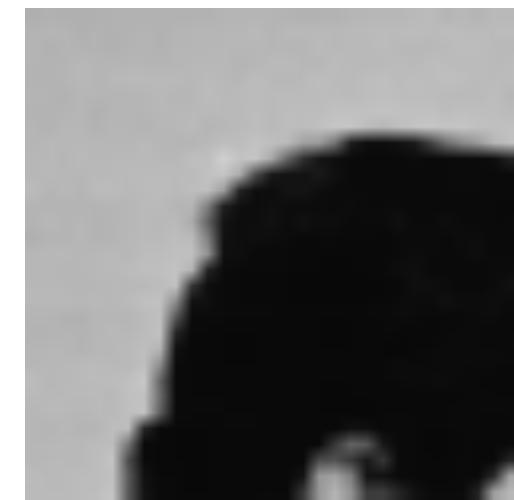


طیف خاکستری



a	b
c	d

FIGURE 2.16
Generating a digital image.
 (a) Continuous image.
 (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization.
 (c) Sampling and quantization.
 (d) Digital scan line.



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20	181	182	178	177	183	182	182	187	192	88	12	11	11	10	10	10	9	9	9	9	9	9	10	11	12	12	10	10	11	12	13	10
21	179	180	182	180	183	186	184	188	194	37	10	10	9	9	9	9	9	9	9	8	9	9	10	10	9	9	11	12	11	10	11	
22	182	183	183	179	183	183	187	190	181	17	9	9	9	8	9	9	9	9	9	9	9	9	9	8	10	11	11	13	11	11	11	
23	183	185	184	187	187	185	185	192	141	12	10	10	9	10	9	10	9	9	9	9	9	9	10	13	11	11	12	11	12	10		
24	189	183	185	186	188	189	192	201	100	11	10	9	10	10	10	10	9	9	9	9	9	9	10	11	12	13	13	11	10	9	9	
25	185	185	185	185	187	184	192	194	109	11	10	10	10	9	10	9	9	10	9	8	9	9	9	9	10	11	11	10	11	10		
26	183	185	185	183	186	186	191	196	95	11	11	10	10	10	10	10	10	9	9	9	9	8	10	10	11	10	11	10	10	10		
27	183	181	184	181	182	189	190	39	11	10	9	9	10	10	10	9	9	9	9	10	9	18	16	10	10	9	10	10	10	9	10	
28	183	184	185	185	188	190	117	11	10	9	8	9	9	9	9	10	9	9	10	56	100	89	25	10	10	8	9	10	10	10	11	
29	183	185	184	184	189	197	78	12	9	10	9	10	10	9	9	9	9	77	82	58	26	55	11	10	10	9	11	9	10	37		
30	188	185	186	189	188	193	92	18	10	10	8	9	9	10	9	9	9	20	152	163	127	21	18	11	10	9	9	11	10	42	165	
31	186	186	186	188	190	197	89	20	10	10	9	10	9	9	10	11	10	57	151	181	146	60	62	37	18	12	11	11	35	160	183	

$P = f(x, y)$

$f : R^2 \Rightarrow R$