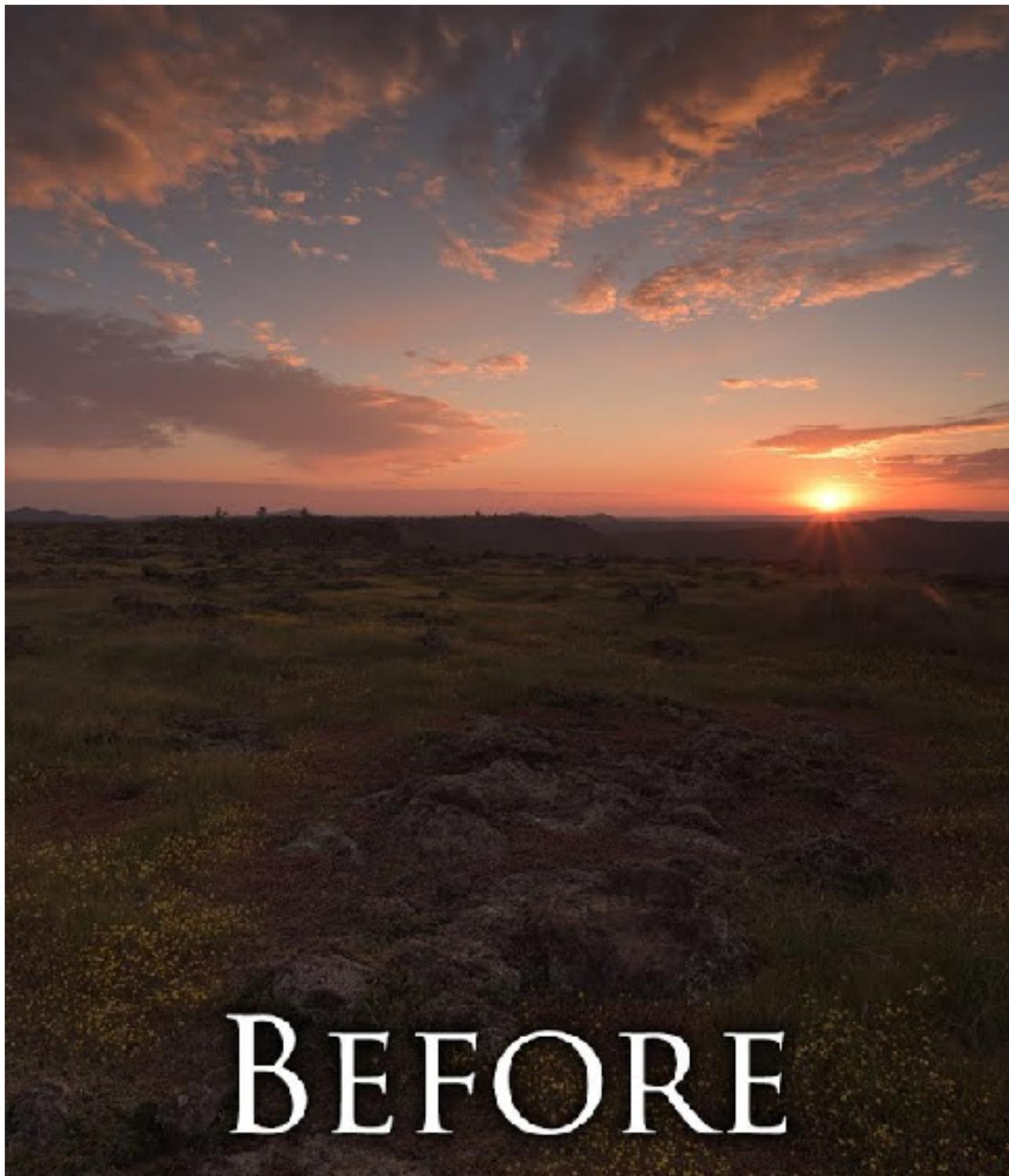


COMP0026: Image Processing

Introduction



BEFORE

COMP0026: Image Processing

Introduction

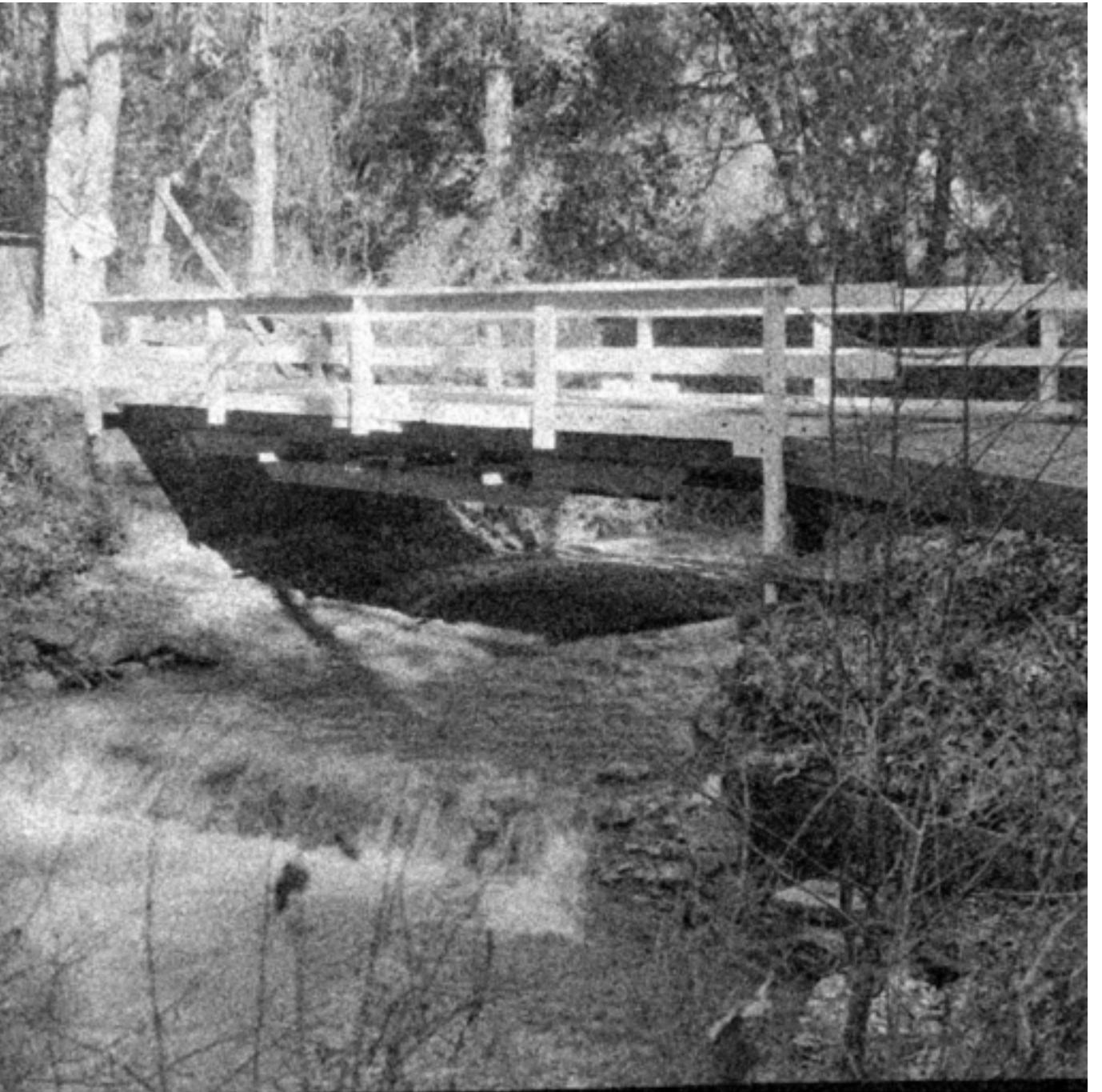


Lectures will be Recorded

Denoising



Denoising



Colorization



Colorization



Image Inpainting

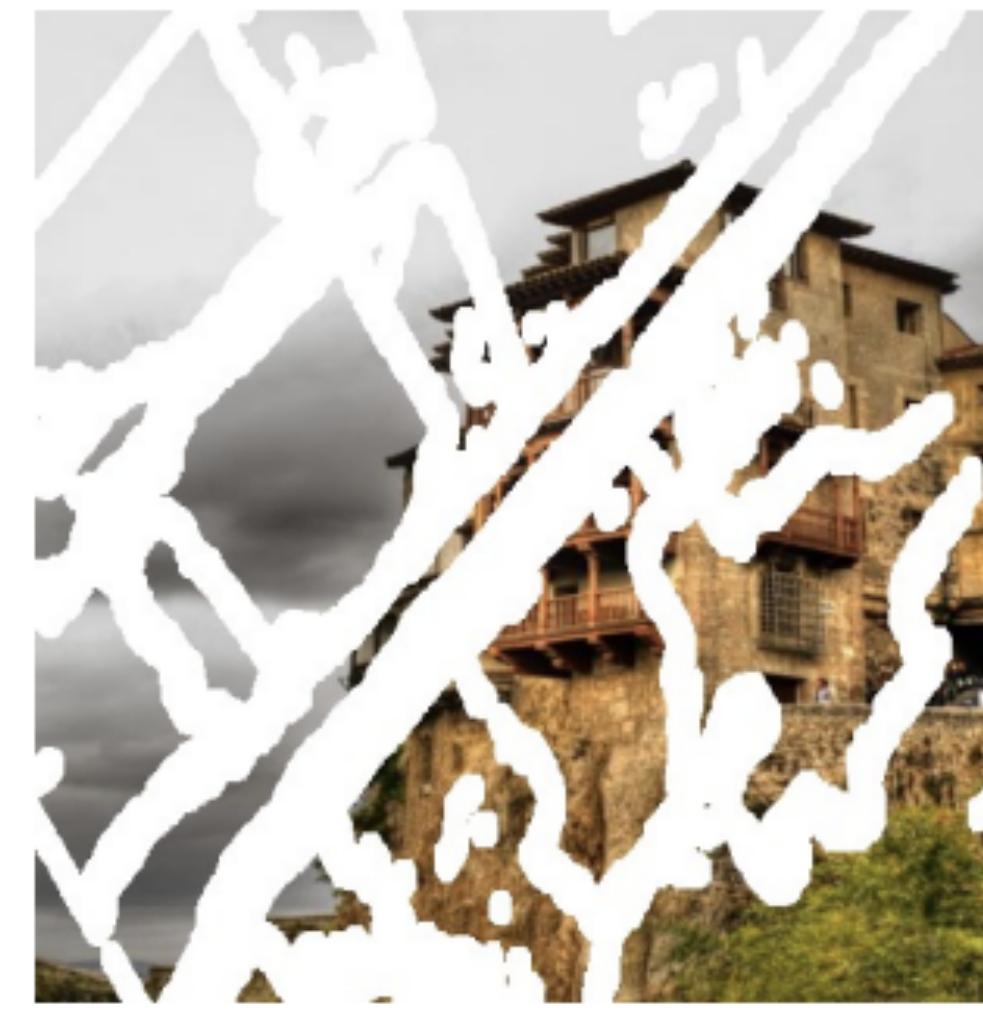
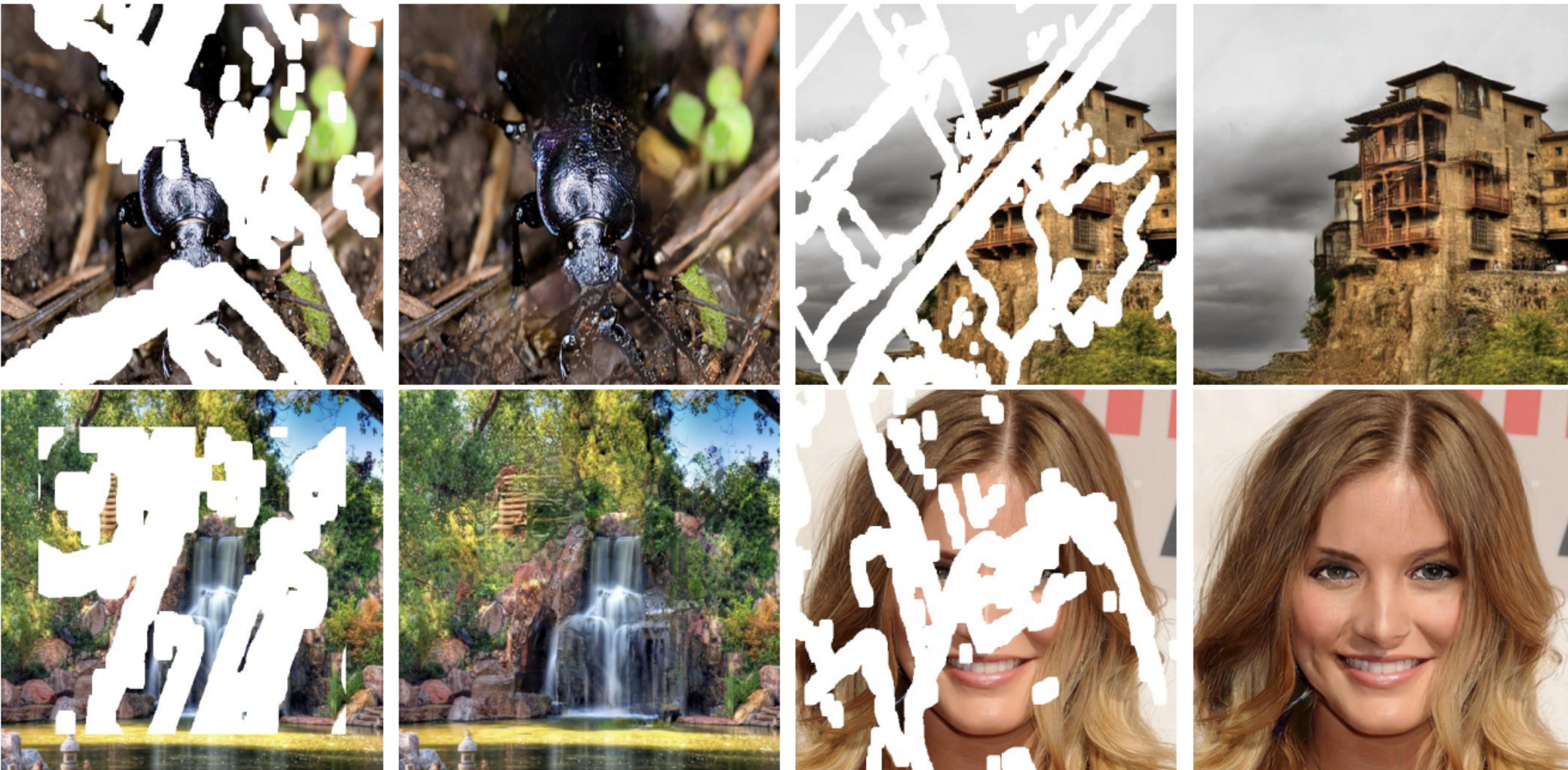


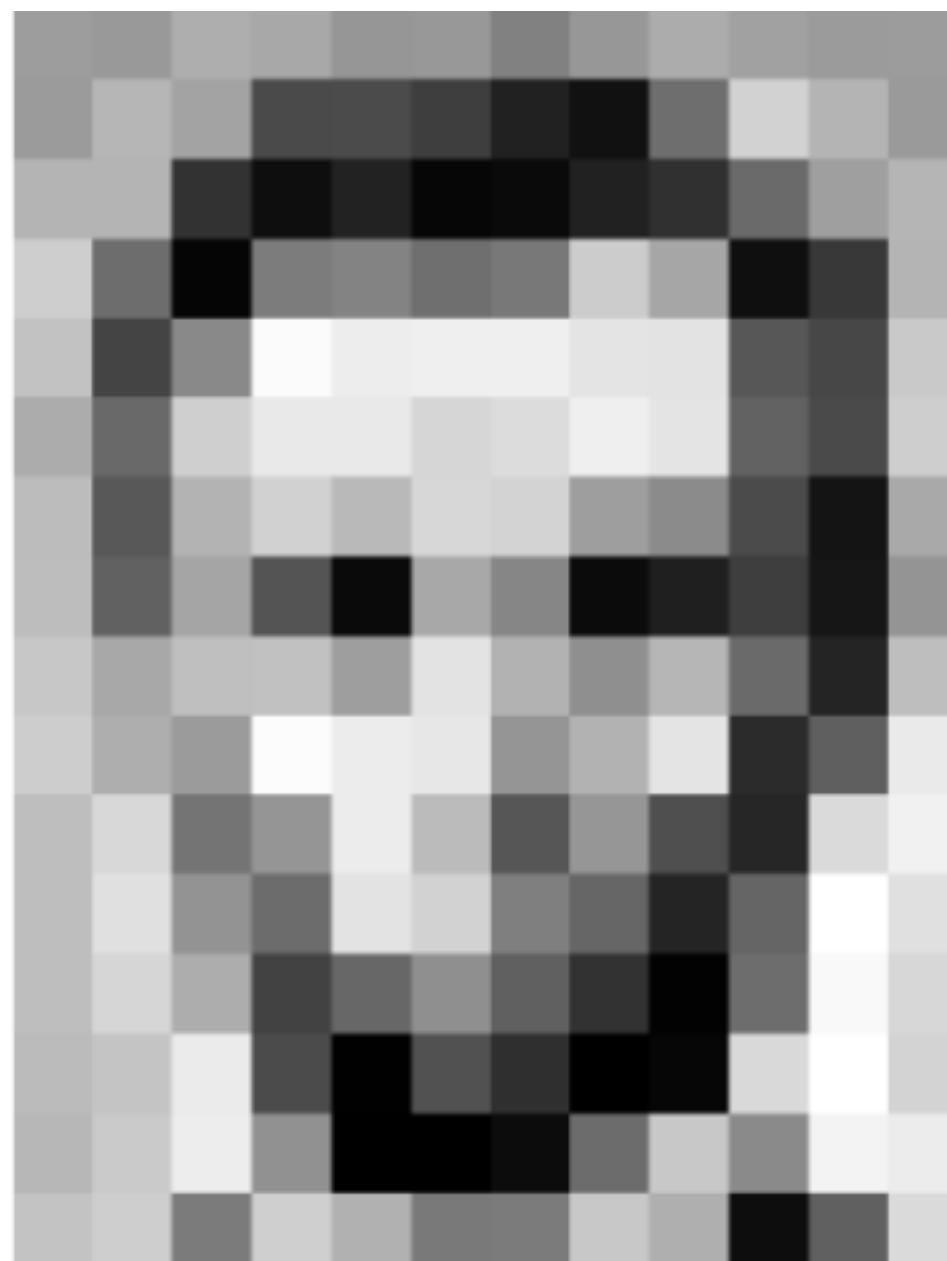
Image Inpainting



Image Inpainting



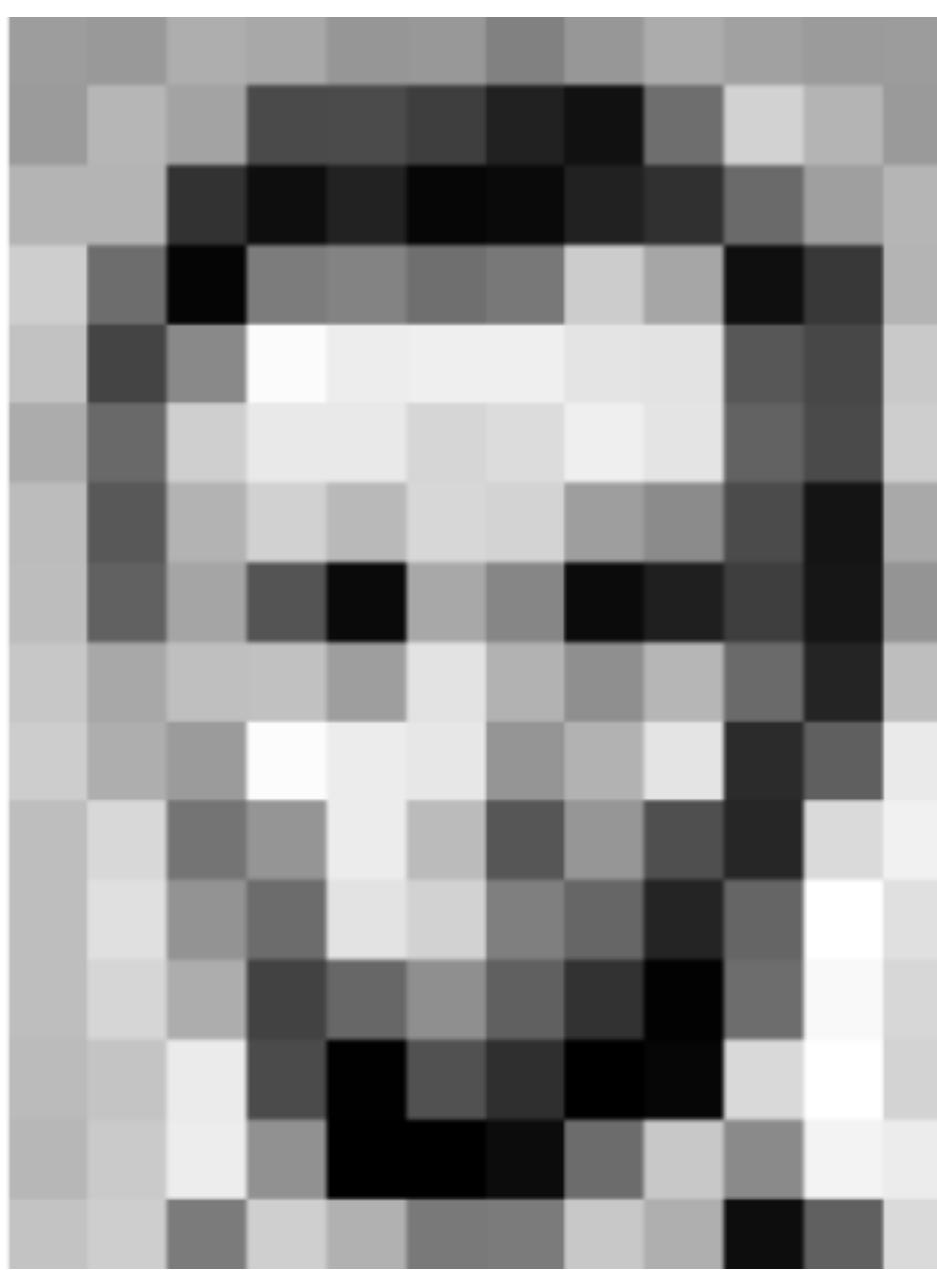
Digital Image



157	159	174	168	150	152	129	151	172	161	155	156				
155	182	163	74	75	62	33	17	110	210	180	154				
180	180	50	14	34	6	10	33	48	106	159	181				
206	109	5	124	131	111	120	204	166	15	56	180				
194	68	137	251	237	239	239	228	227	87	71	201				
172	106	207	233	233	214	220	239	228	98	74	206				
188	68	179	209	185	215	211	158	139	75	20	169				
189	97	165	84	10	168	134	11	31	62	22	148				
199	168	191	193	158	227	178	143	182	106	36	190				
205	174	155	252	236	231	149	178	228	43	95	234				
190	216	116	149	256	187	85	150	79	38	218	241				
190	224	147	168	227	210	127	102	56	101	255	224				
190	214	173	66	103	143	95	50	2	109	249	215				
187	196	235	75	1	81	67	9	6	217	255	211				
183	202	237	145	0	0	12	108	209	138	243	236				
195	206	123	207	177	121	123	200	175	13	96	218				

157	159	174	168	150	152	129	151	172	161	155	156				
155	182	163	74	75	62	33	17	110	210	180	154				
180	180	50	14	34	6	10	33	48	106	159	181				
206	109	5	124	131	111	120	204	166	15	56	180				
194	68	137	251	237	239	239	228	227	87	71	201				
172	106	207	233	233	214	220	239	228	98	74	206				
188	68	179	209	185	215	211	158	139	75	20	169				
189	97	165	84	10	168	134	11	31	62	22	148				
199	168	191	193	158	227	178	143	182	106	36	190				
205	174	155	252	236	231	149	178	228	43	95	234				
190	216	116	149	256	187	85	150	79	38	218	241				
190	224	147	168	227	210	127	102	56	101	255	224				
190	214	173	66	103	143	95	50	2	109	249	215				
187	196	235	75	1	81	67	9	6	217	255	211				
183	202	237	145	0	0	12	108	209	138	243	236				
195	206	123	207	177	121	123	200	175	13	96	218				

Digital Image



157	159	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	6	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	68	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	96	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	256	187	85	150	79	38	218	241
190	224	147	168	227	210	127	102	56	101	255	224
190	214	173	66	103	143	95	50	2	109	249	215
187	196	236	75	1	81	67	9	6	217	255	211
183	202	237	145	0	9	12	108	209	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

157	159	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	6	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	68	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	96	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	256	187	85	150	79	38	218	241
190	224	147	168	227	210	127	102	56	101	255	224
190	214	173	66	103	143	95	50	2	109	249	215
187	196	236	75	1	81	67	9	6	217	255	211
183	202	237	145	0	9	12	108	209	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

Images as multidimensional arrays and matrices

Single Channel

0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	0	1	0	1	0

8	120	221	189	145	212	33	244
149	20	30	72	205	177	208	173
47	19	3	249	302	229	161	122
0	76	198	197	28	147	107	93
243	40	131	54	150	18	11	158
123	66	137	10	139	111	241	183
239	217	300	153	131	236	230	113
237	166	62	169	129	32	141	185

1 bit per pixel.

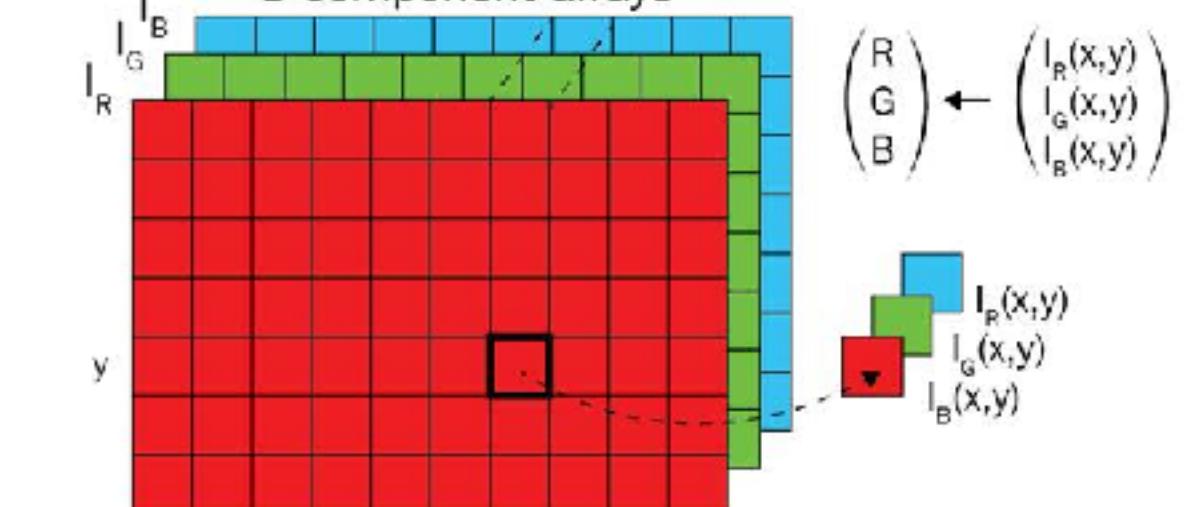
Values 0 – 1

Height x Width

Multi Channel

Color(RGB)

3 component arrays



24 bits per pixel.

RB Red/Green/Blue

Height x Width x 3:

Image Processing

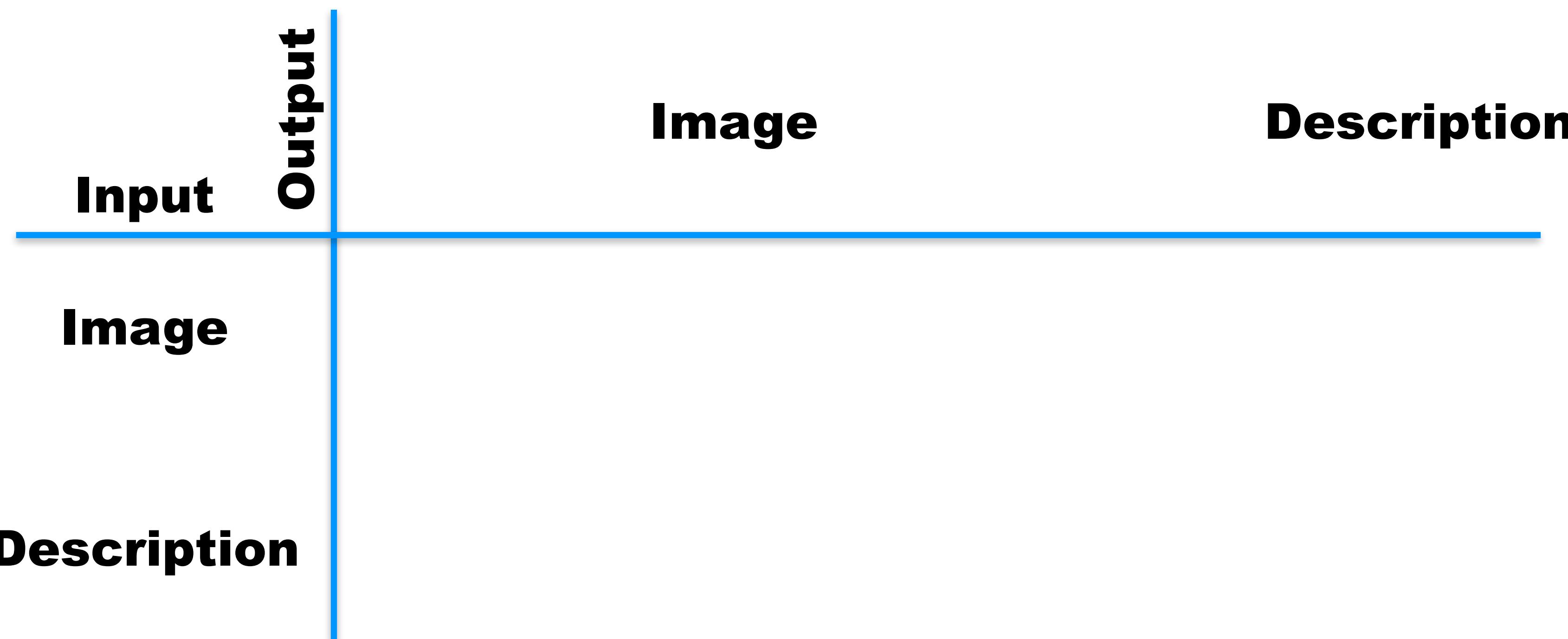


Image Processing



Image Processing

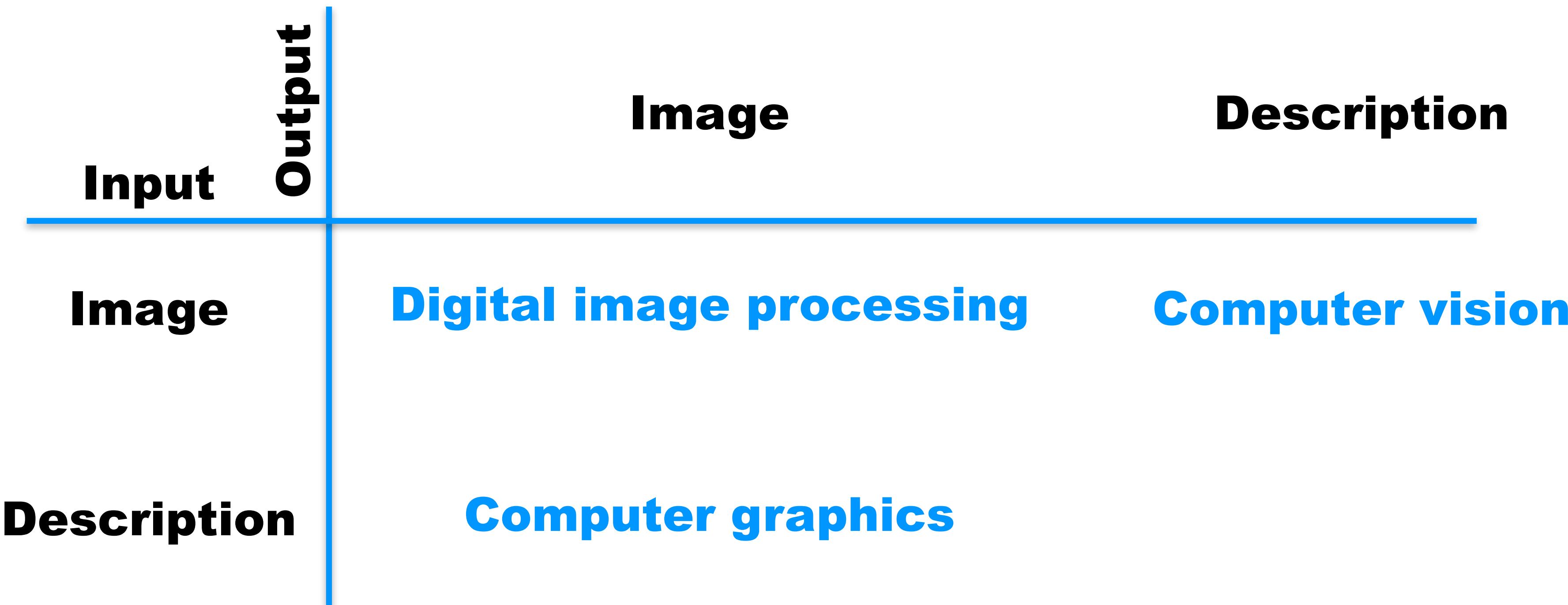
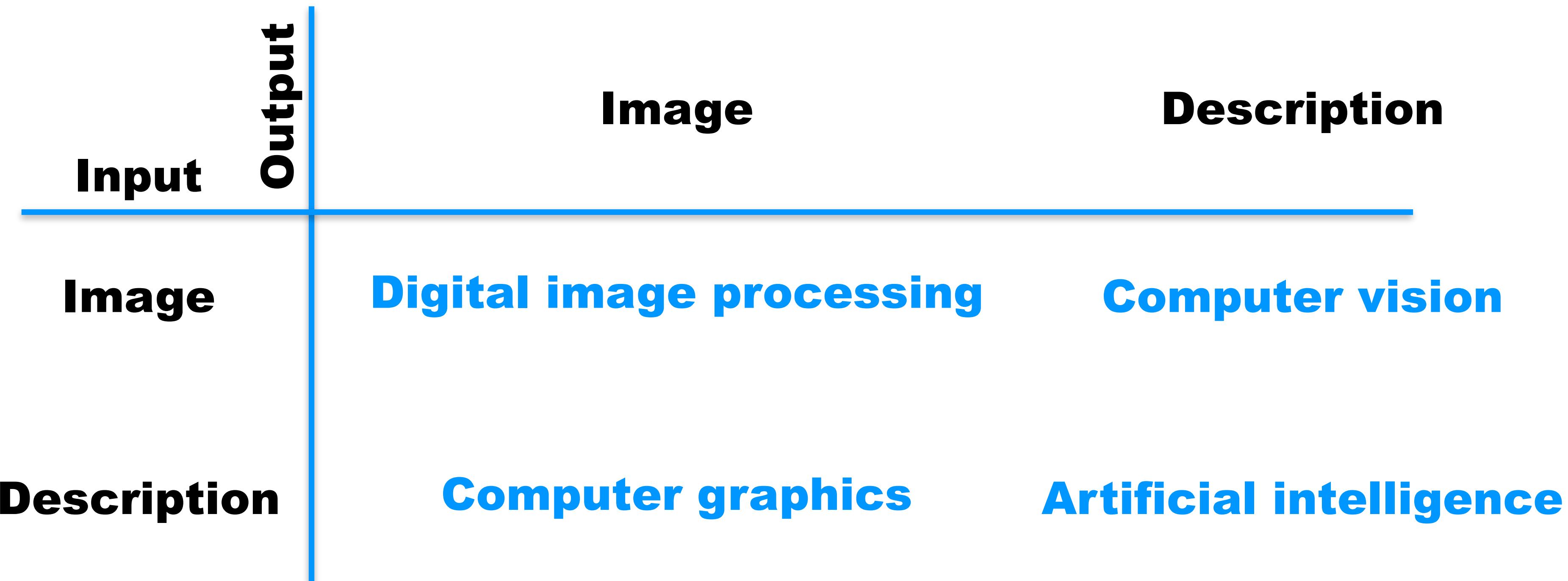
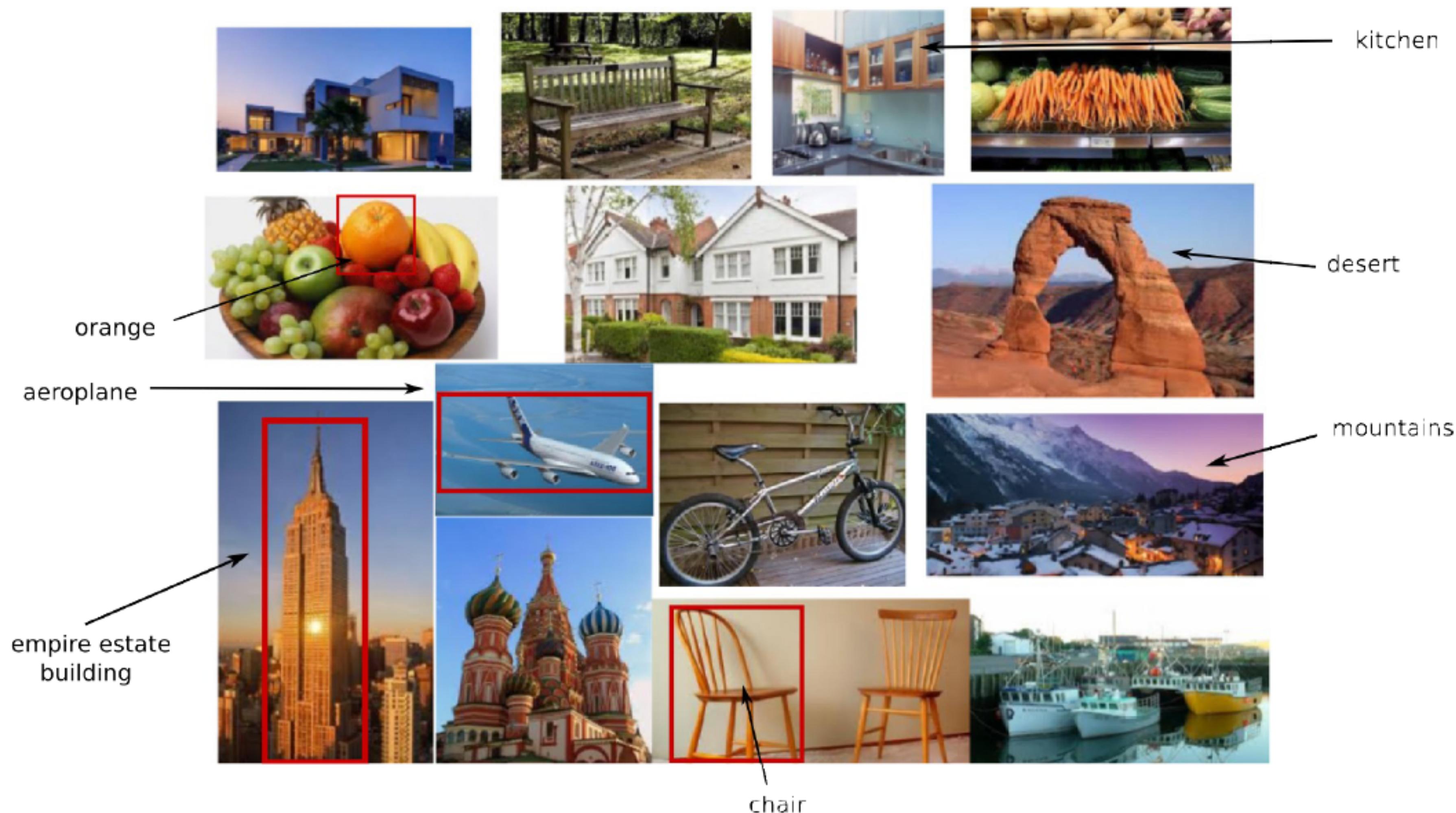


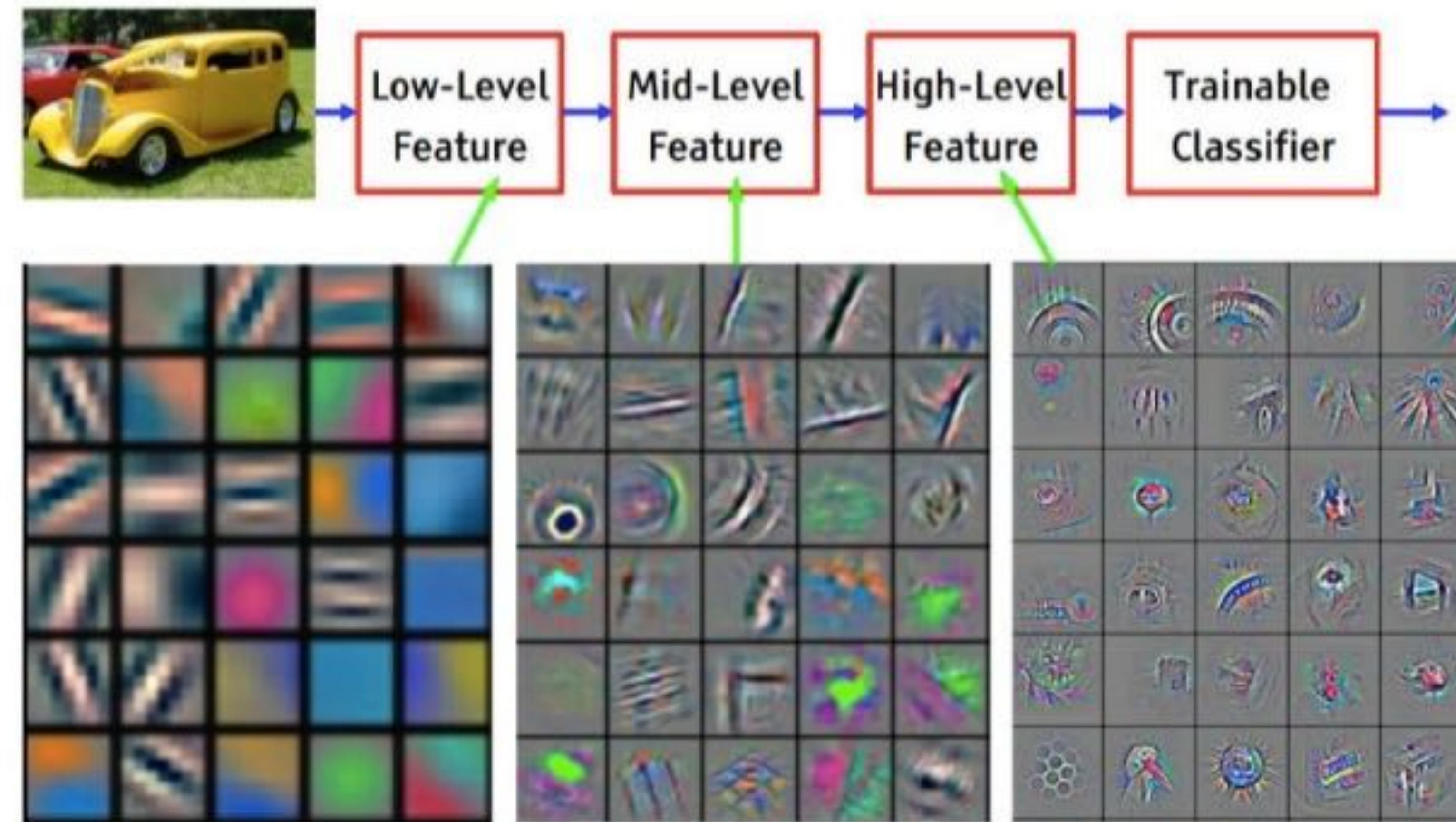
Image Processing



Motivation: Model and Understand the World



Traditional vs Deep Learning Approaches



Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

Image Formation and Settings

Image Formation and Settings

Image formation

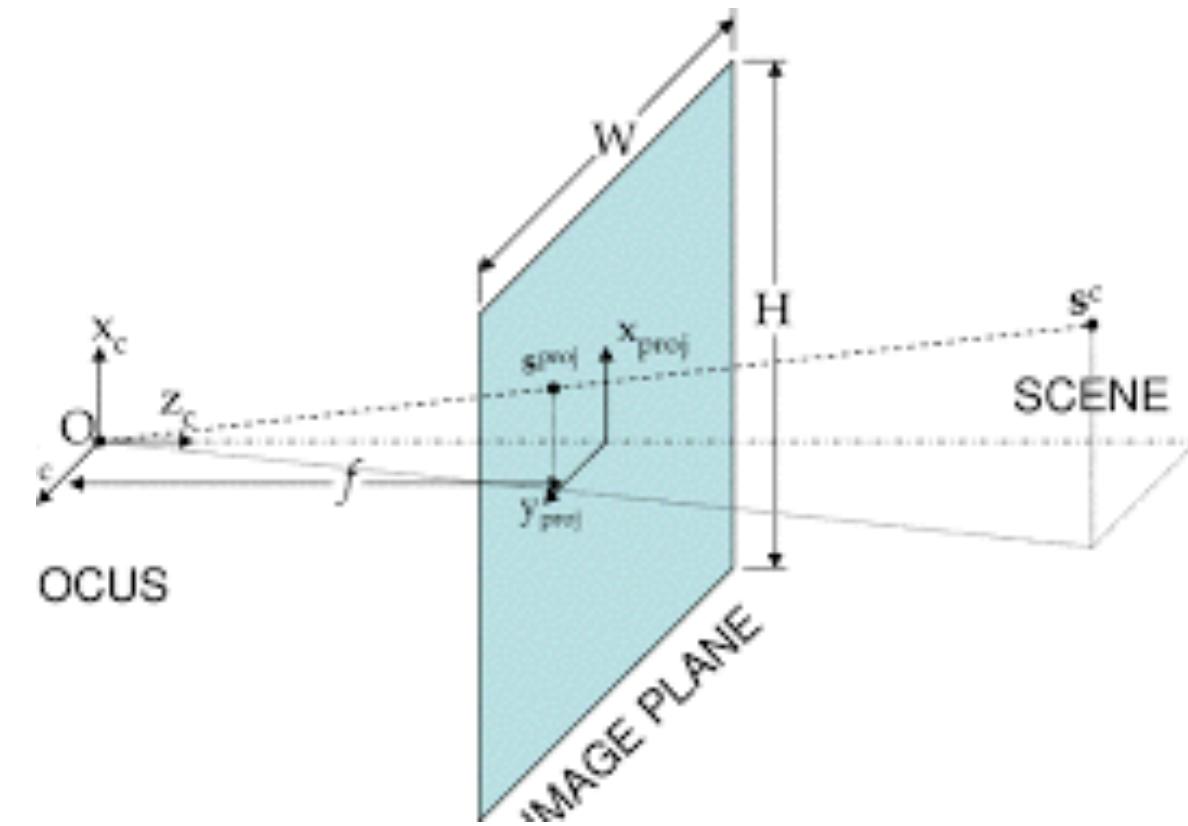
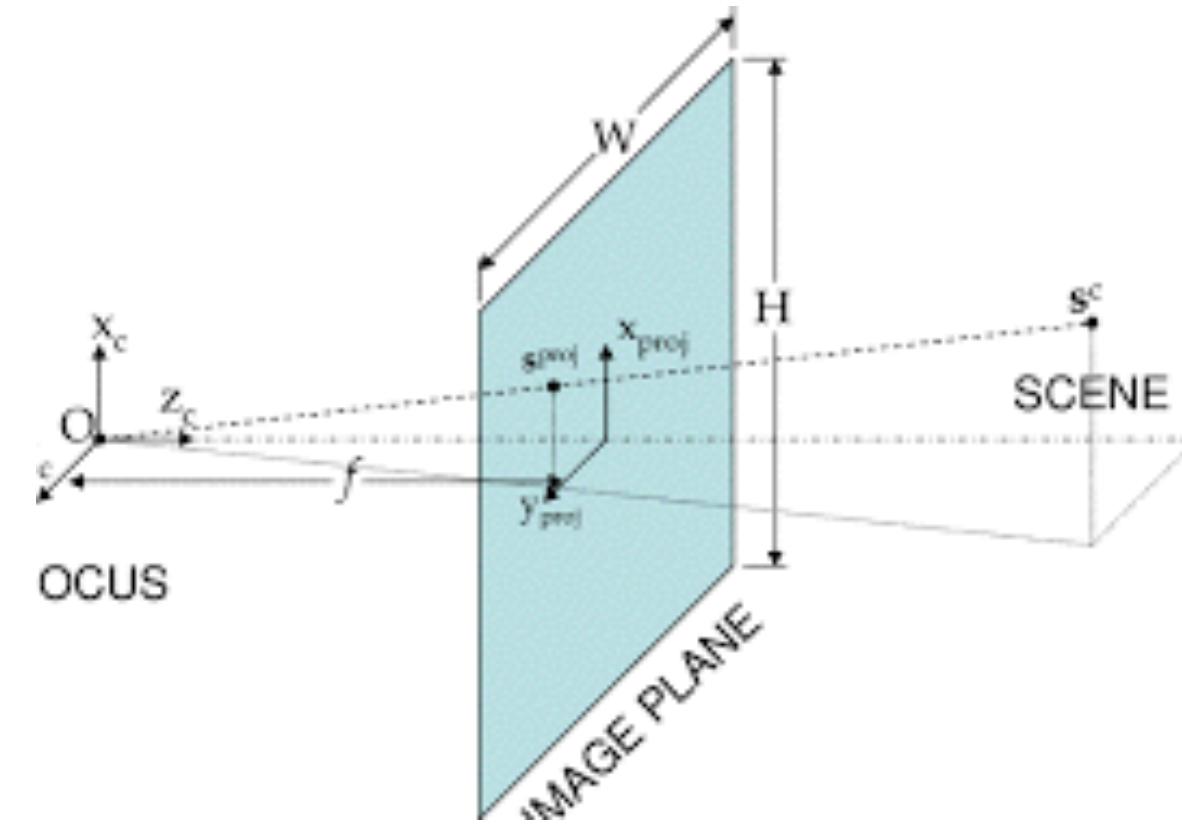


Image Formation and Settings

Image formation



Sensors

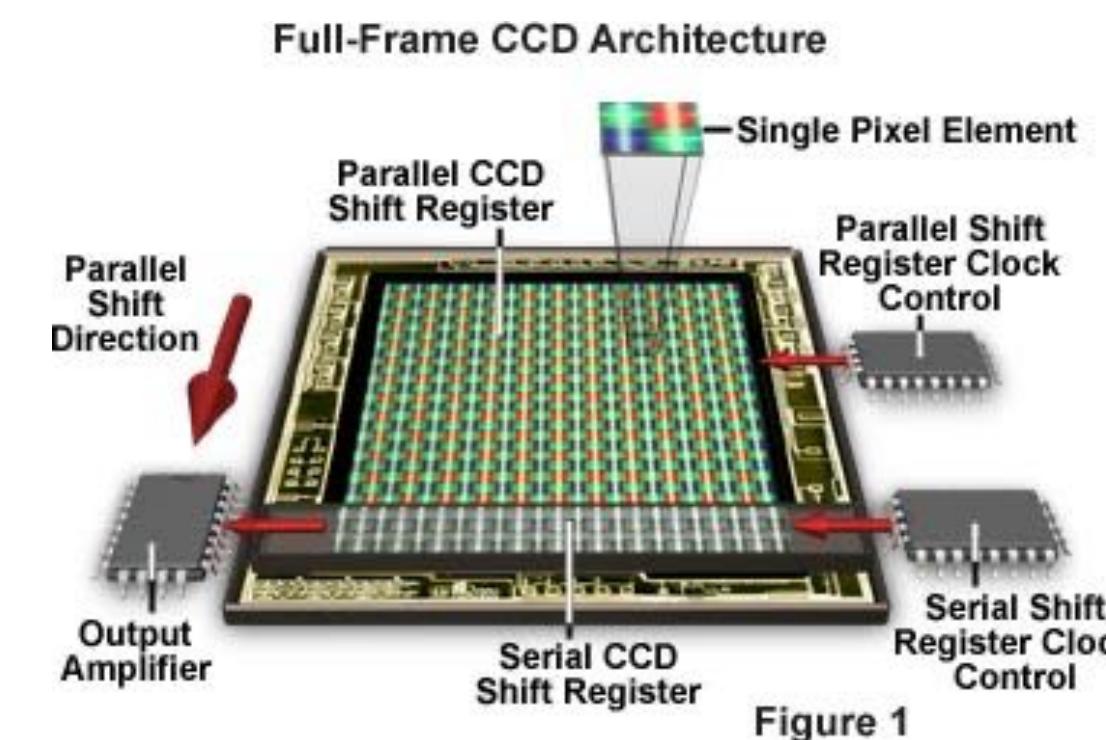
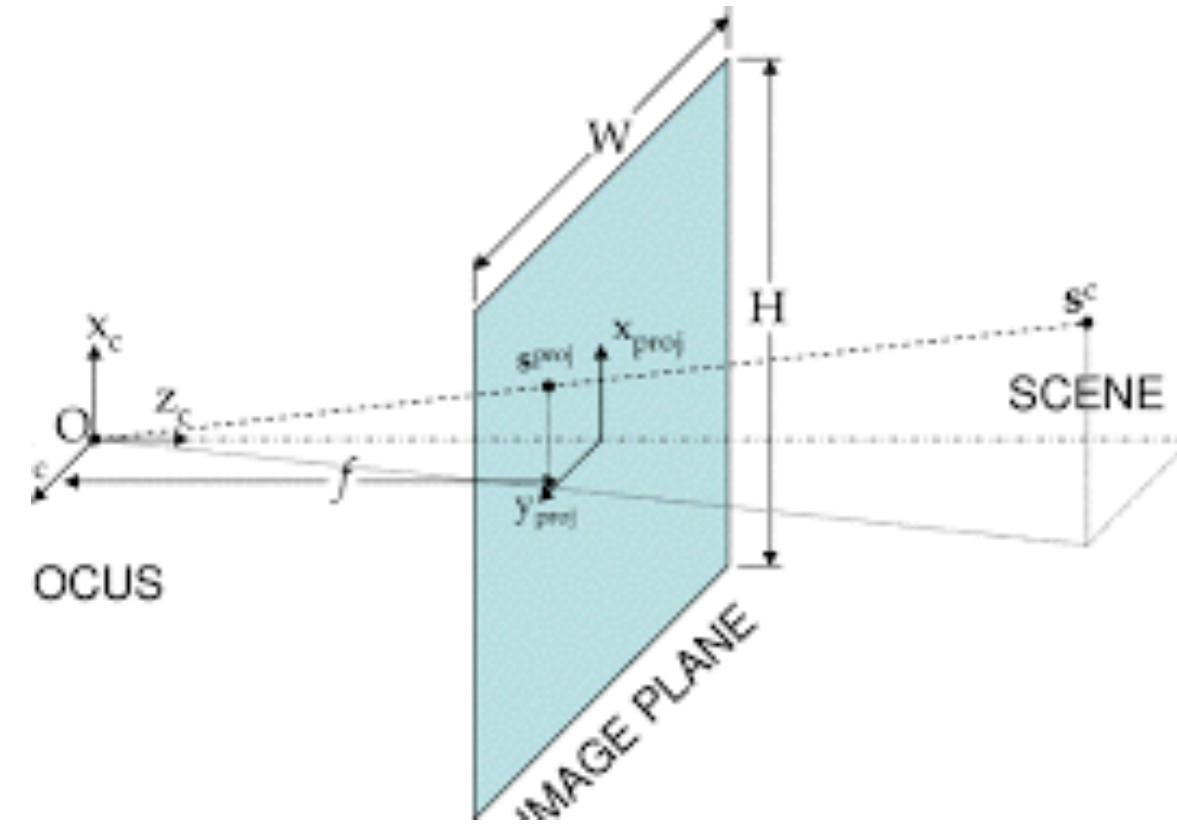
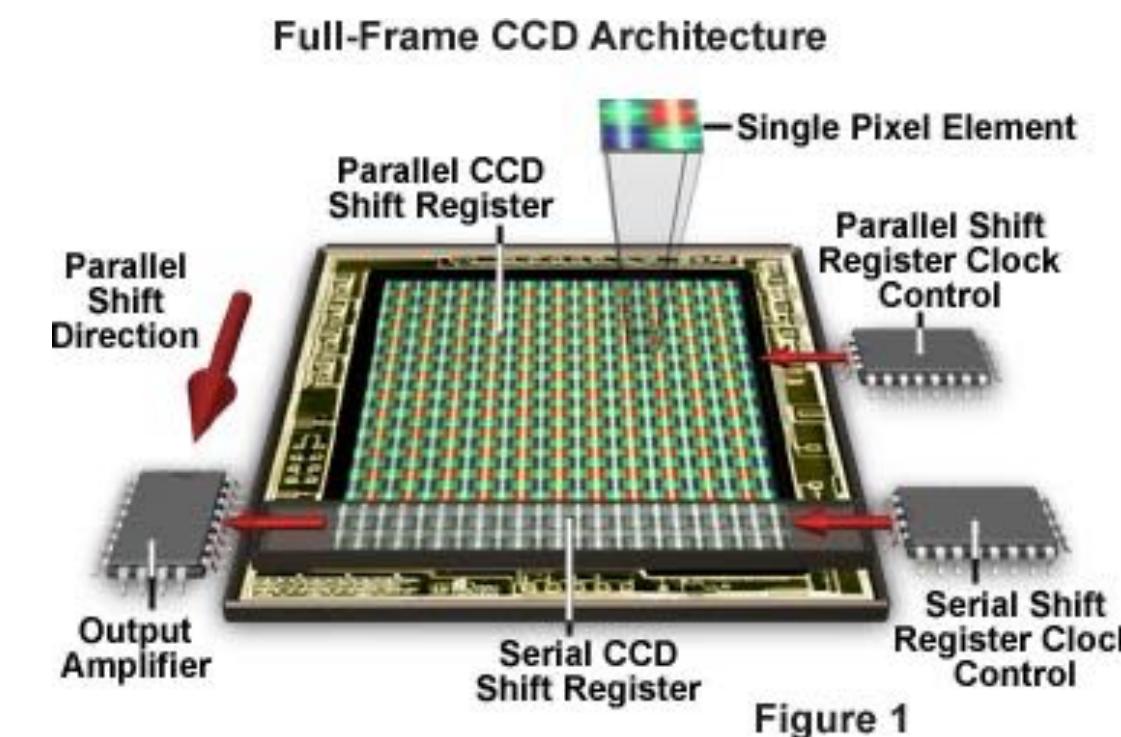


Image Formation and Settings

Image formation



Sensors



Sampling

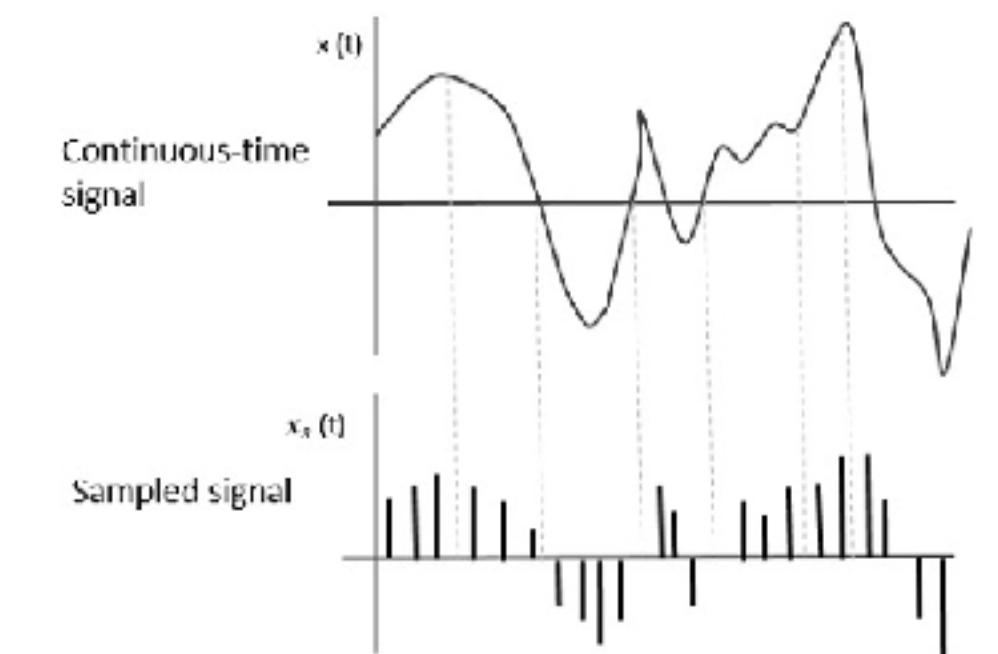
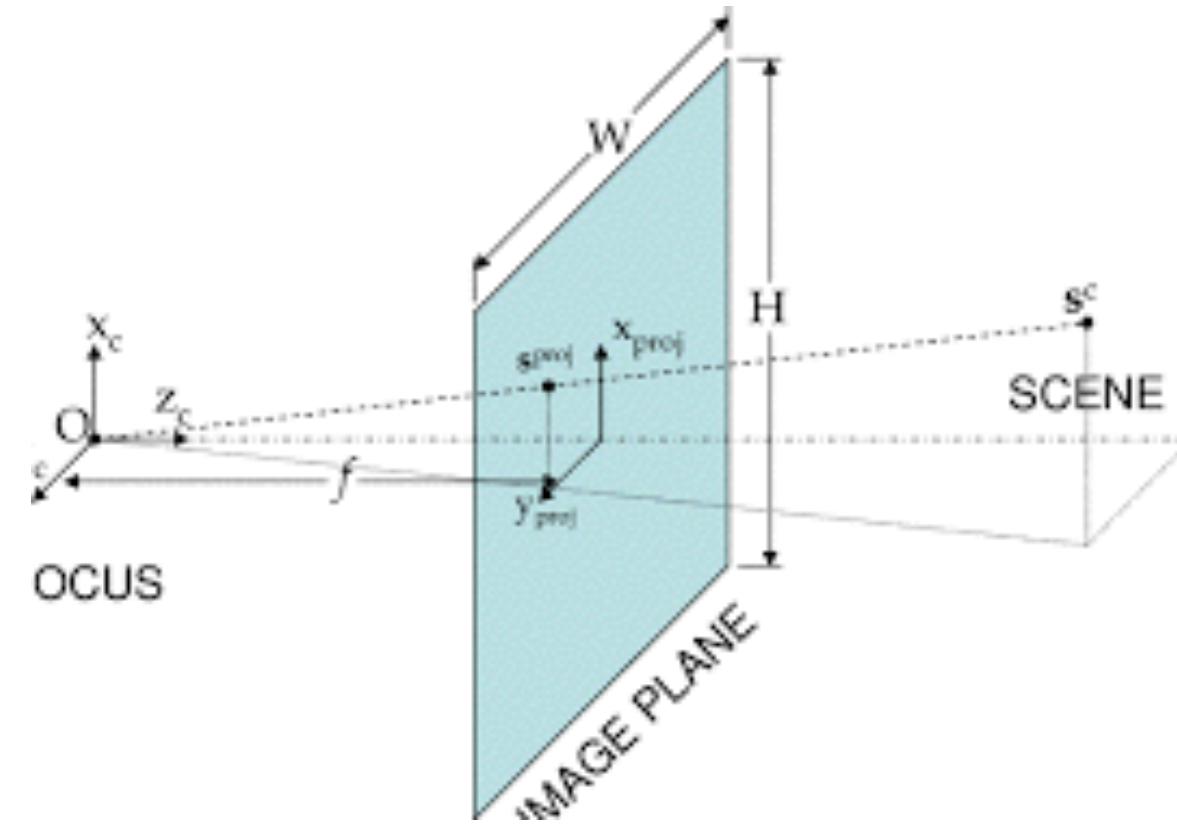
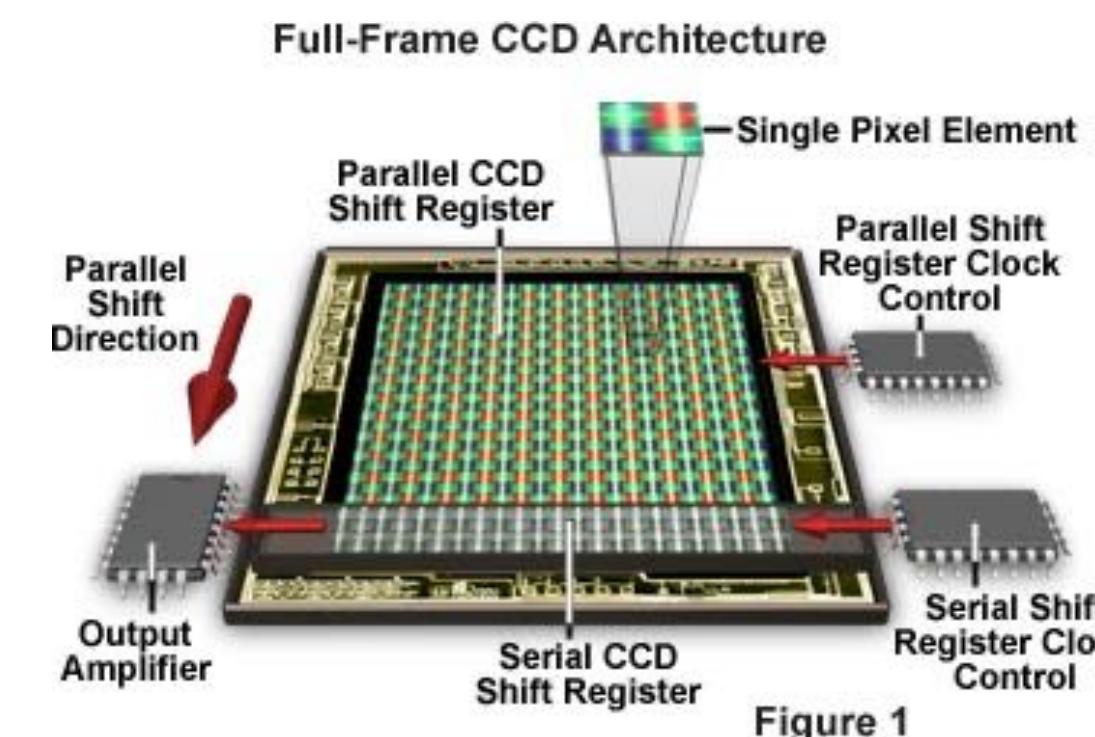


Image Formation and Settings

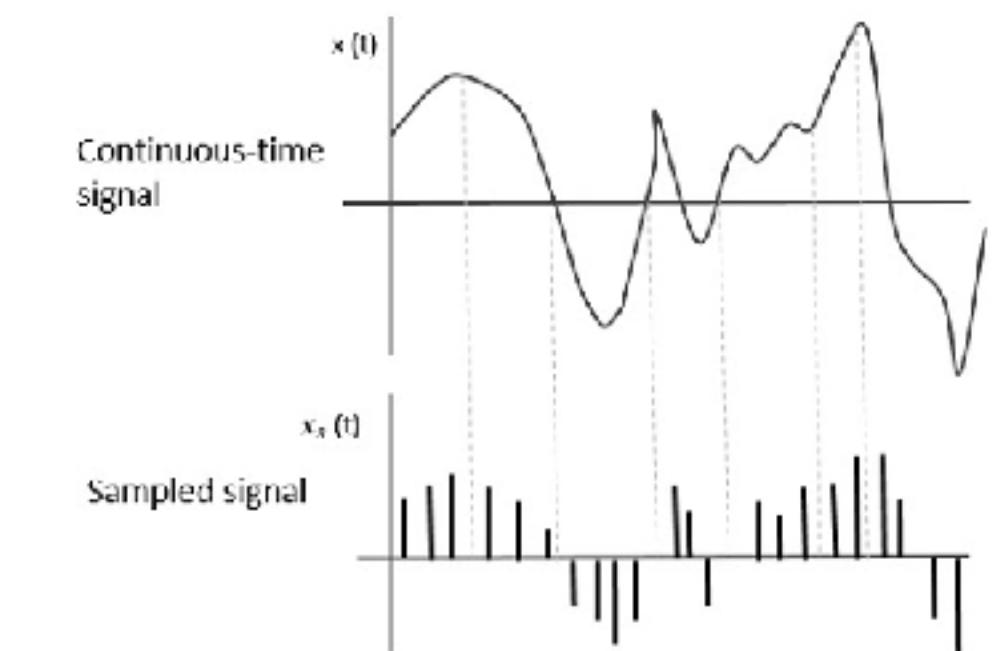
Image formation



Sensors



Sampling



Aliasing

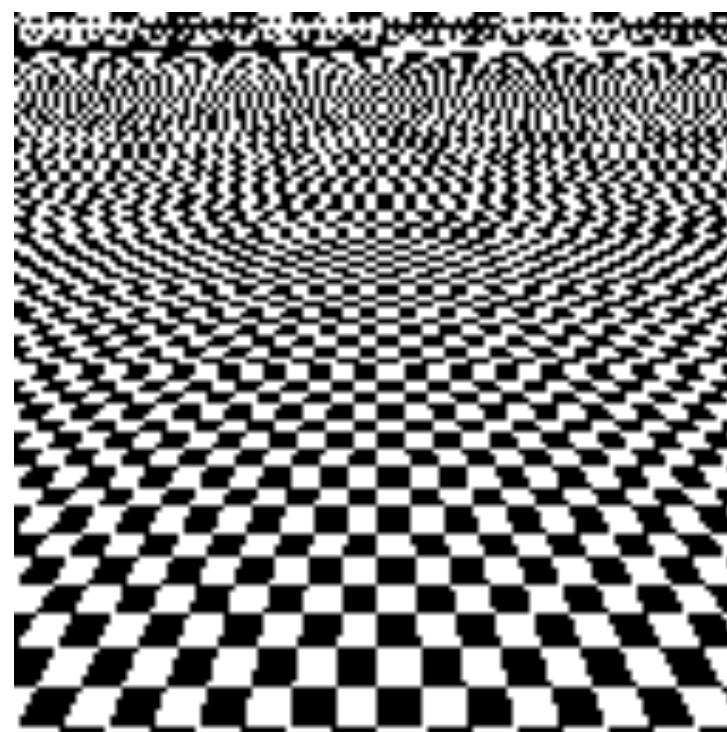
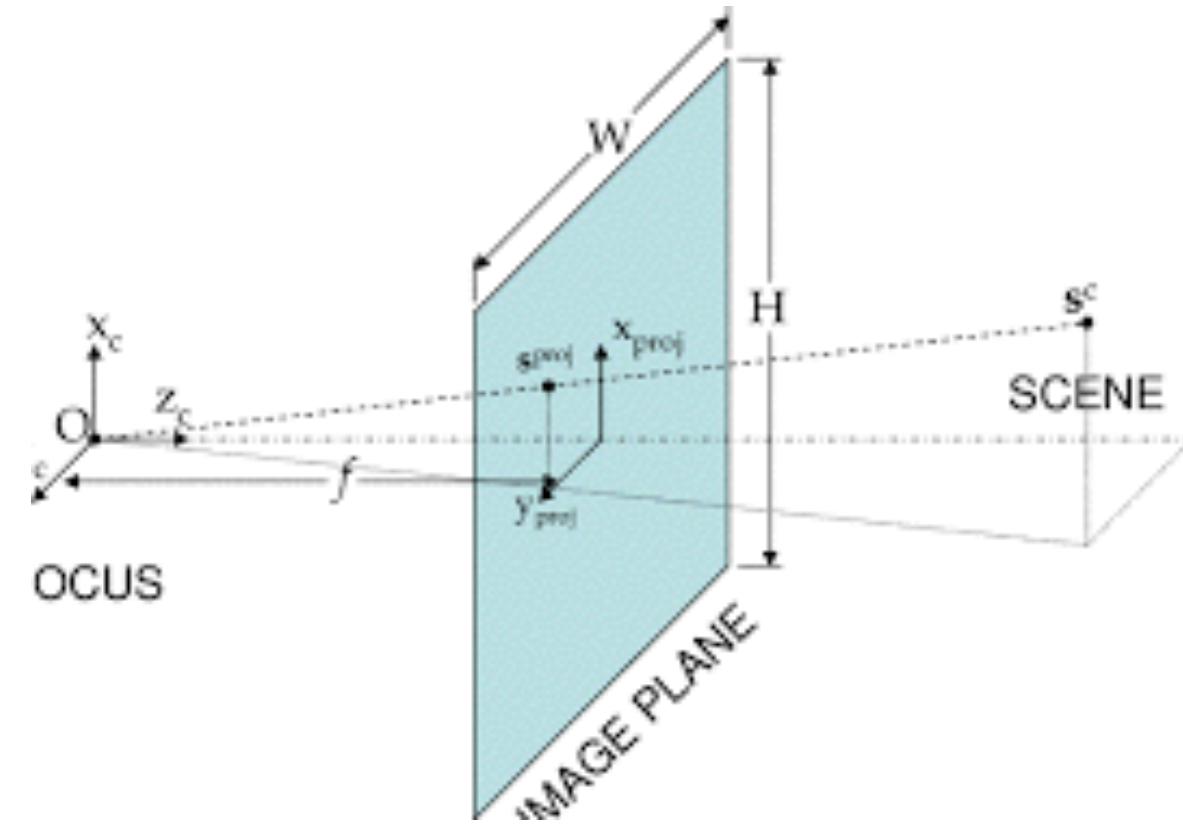
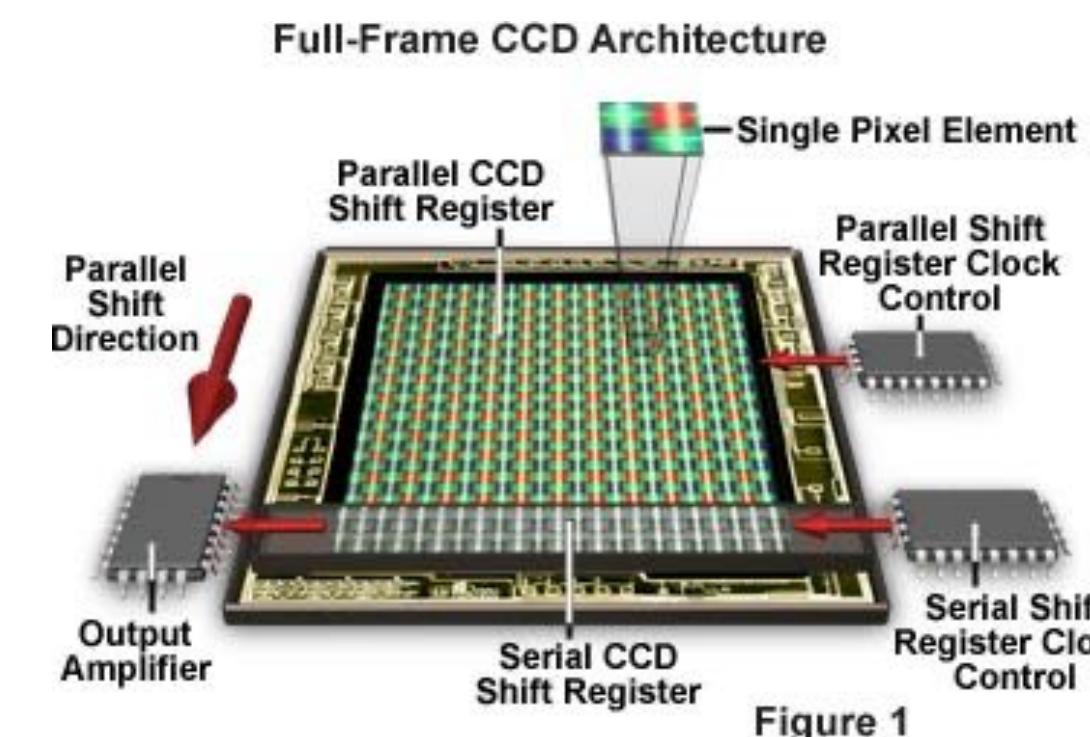


Image Formation and Settings

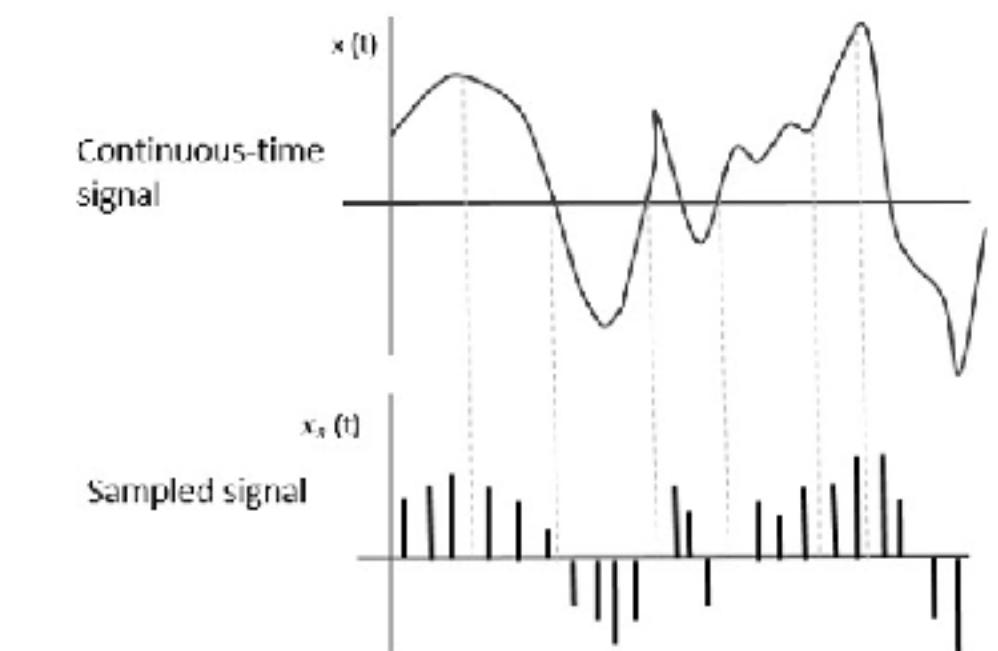
Image formation



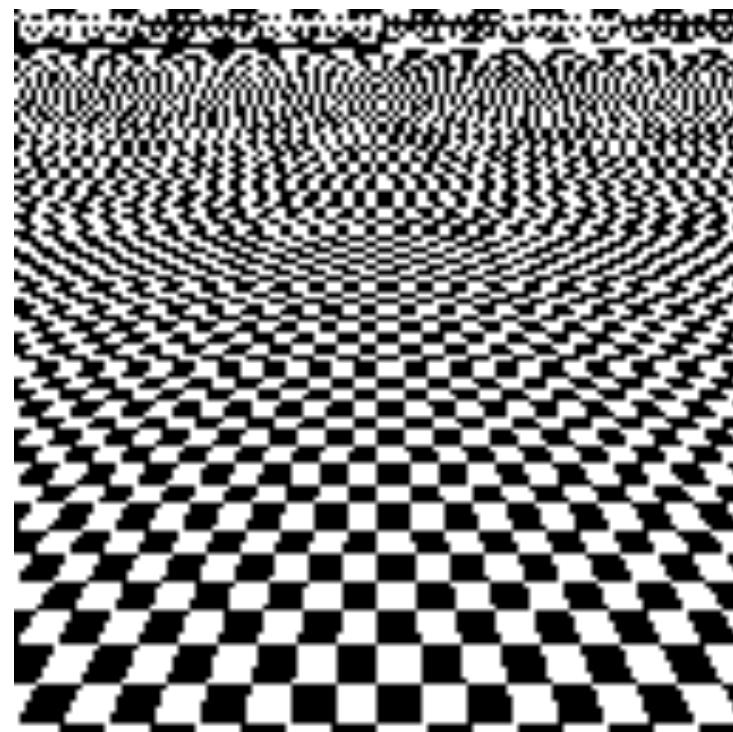
Sensors



Sampling



Aliasing



Quantization

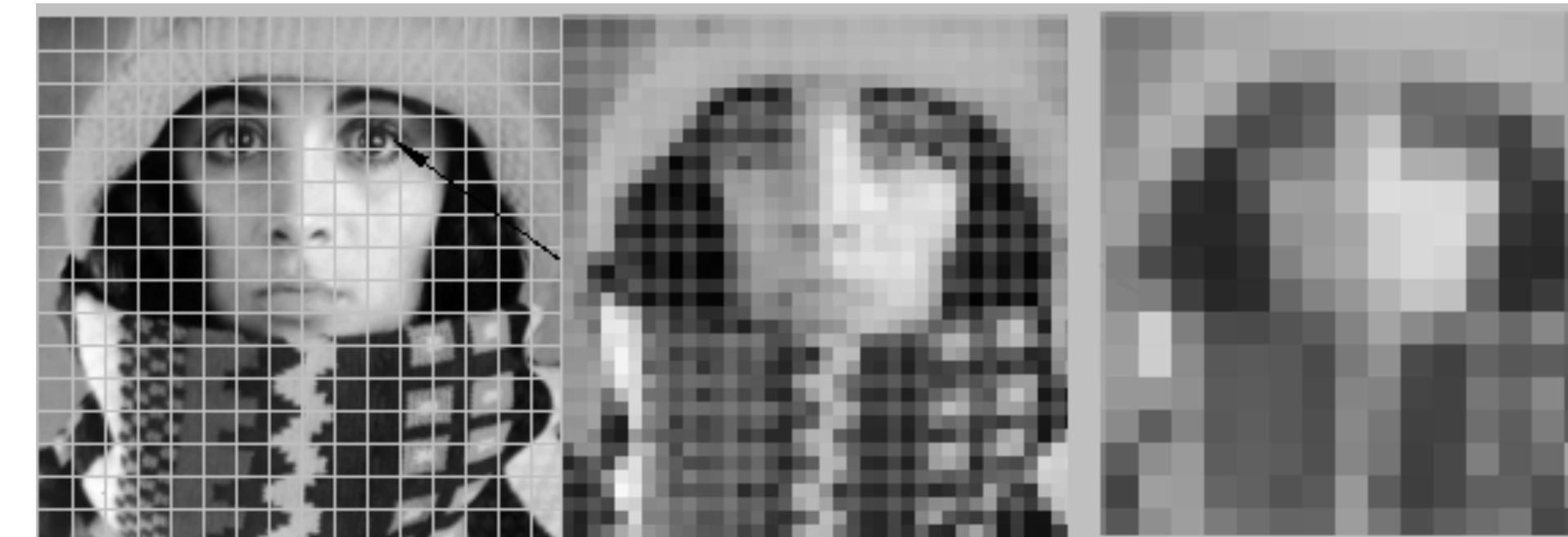
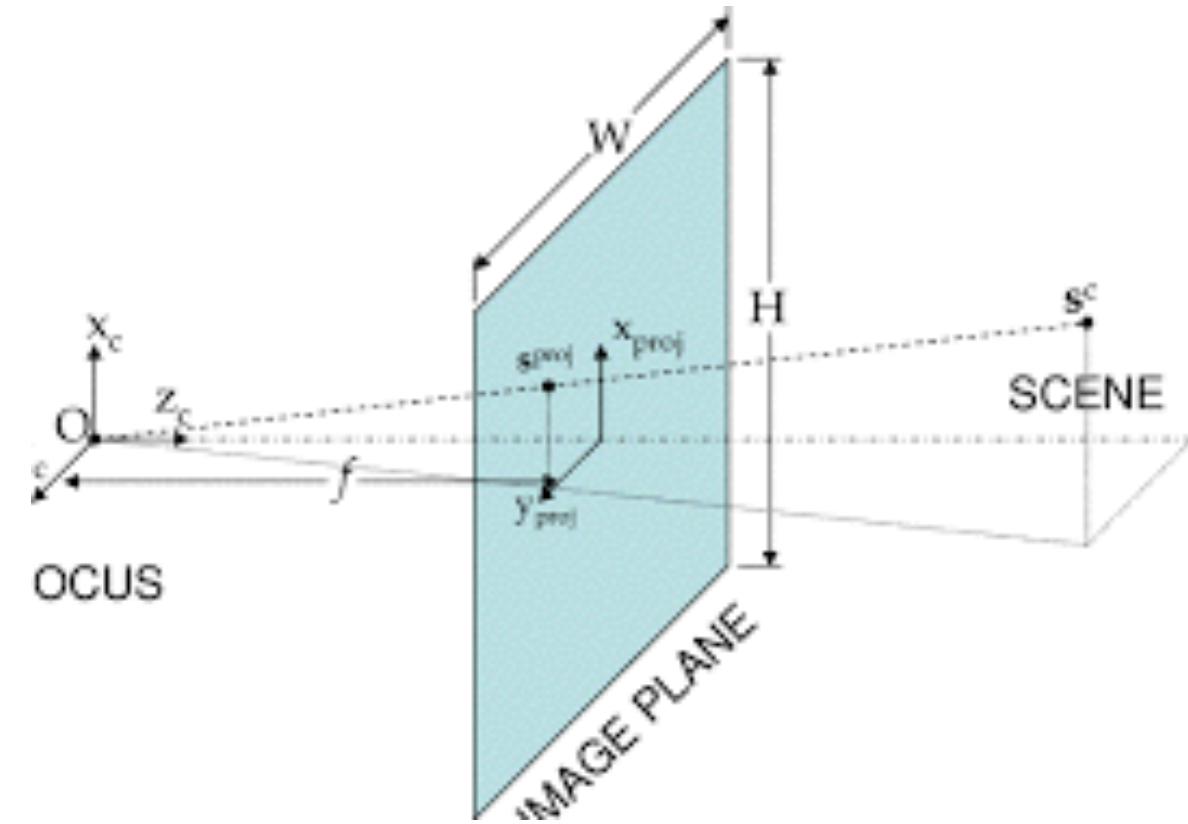
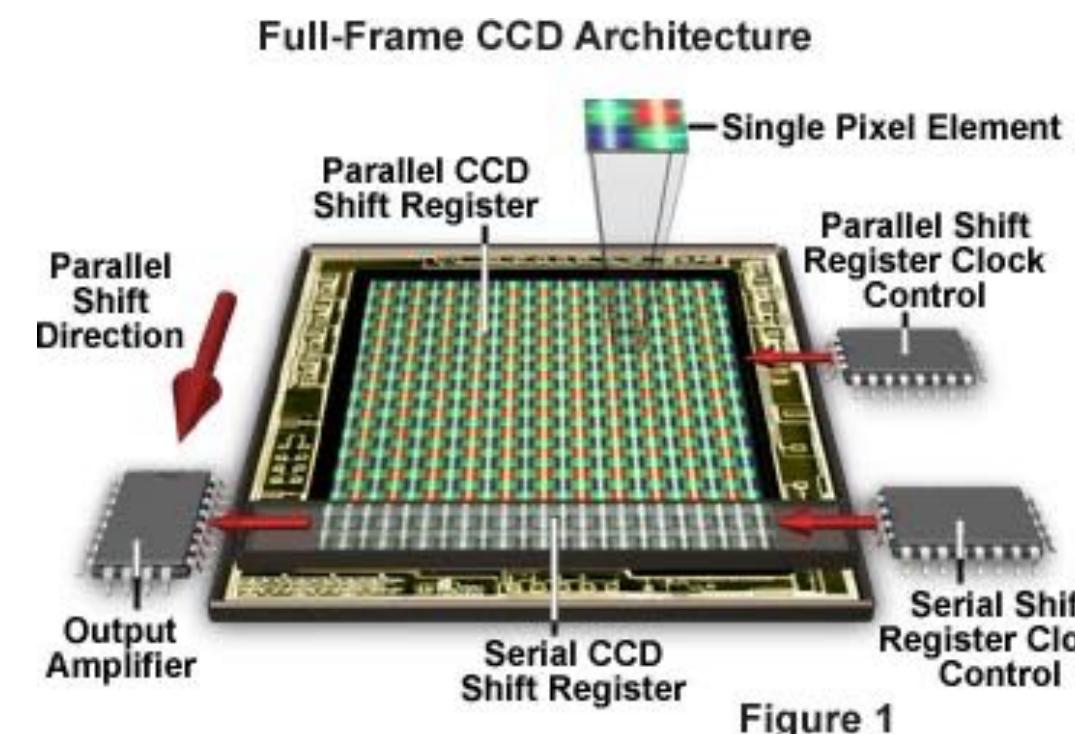


Image Formation and Settings

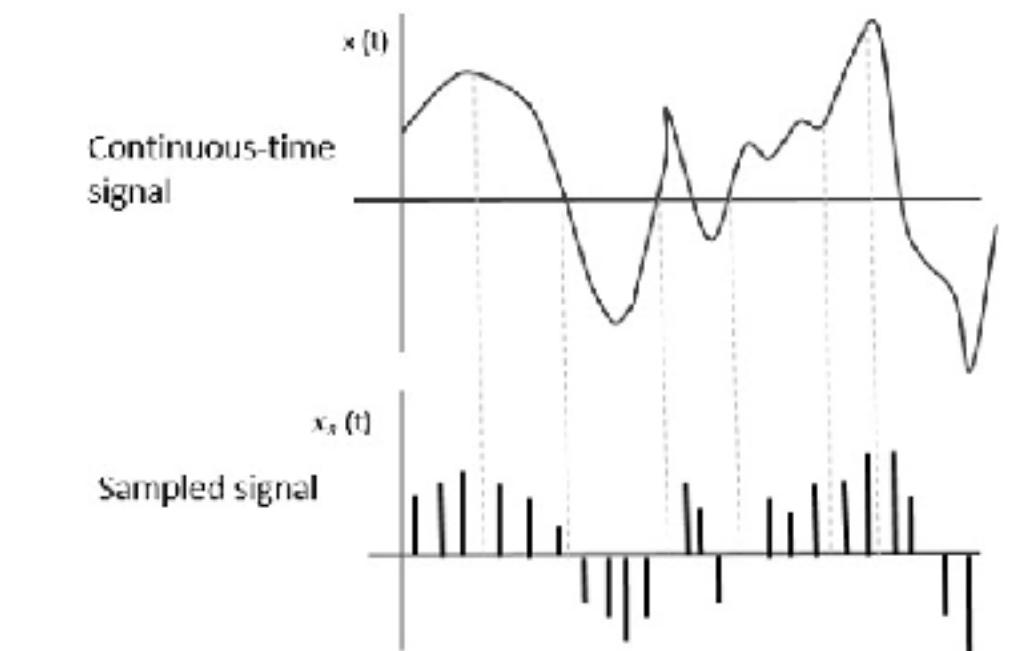
Image formation



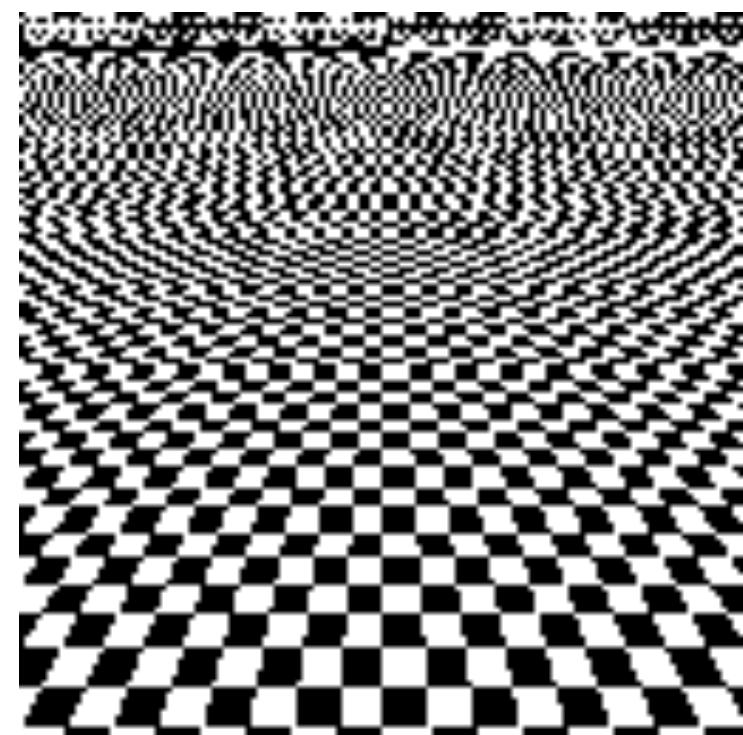
Sensors



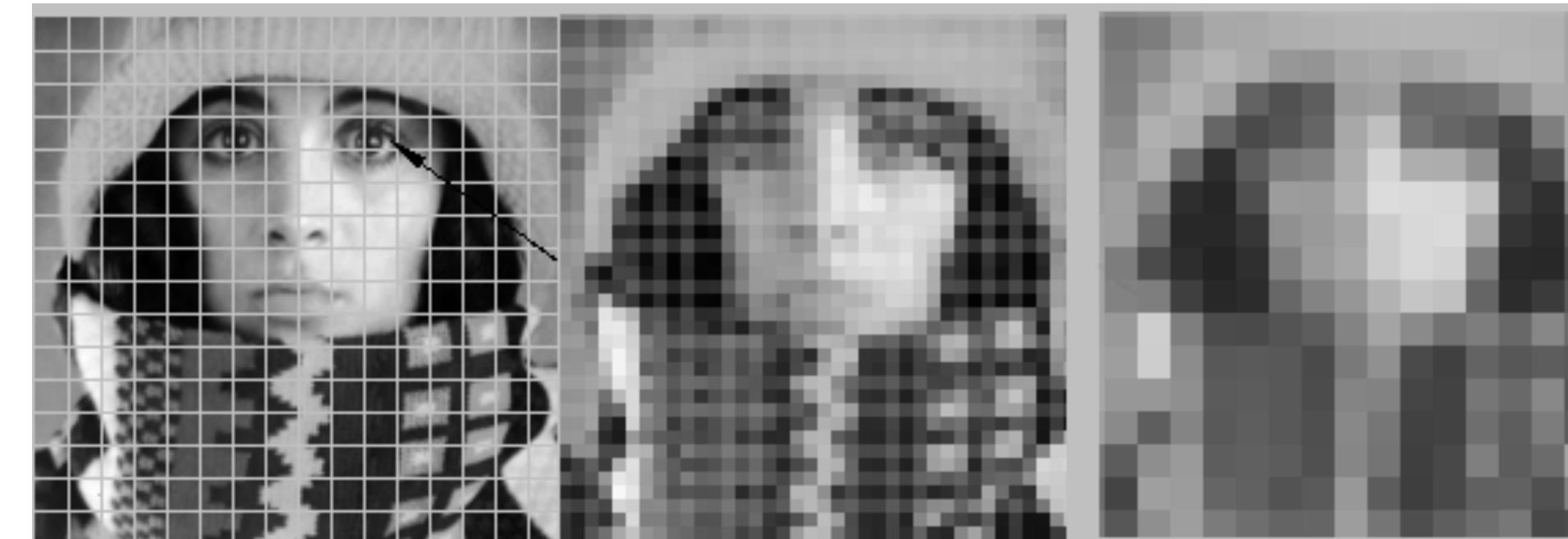
Sampling



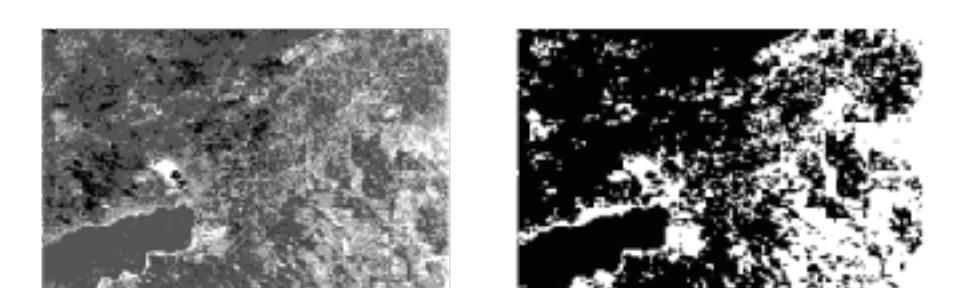
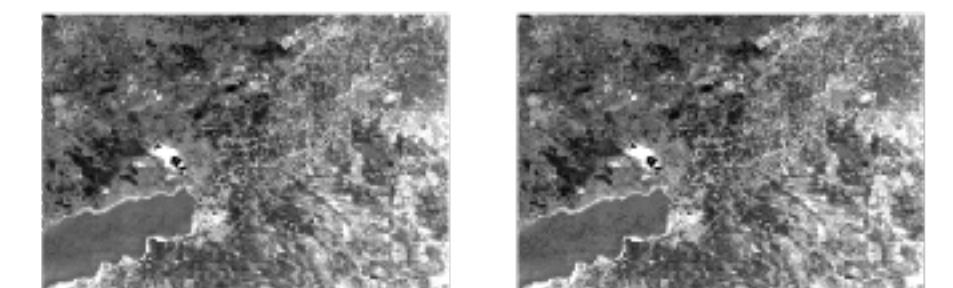
Aliasing



Quantization



Resolution



This work is licensed under a [Creative Commons Attribution-ShareAlike license](http://creativecommons.org/licenses/by-sa/4.0/). Author: <http://www.cs.ucl.ac.uk/staff/afrey/teach/>

Image Segmentation

Image Segmentation

Segmentation



Pepper



Segmented Pepper



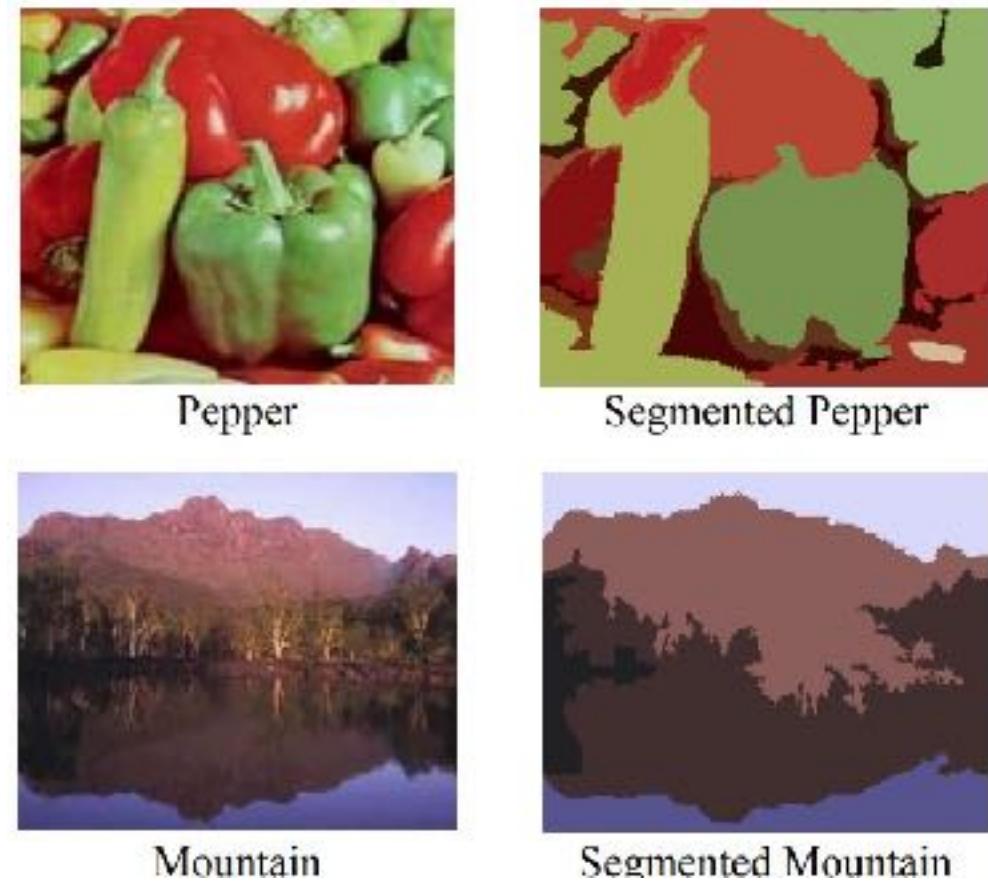
Mountain



Segmented Mountain

Image Segmentation

Segmentation



Thresholding

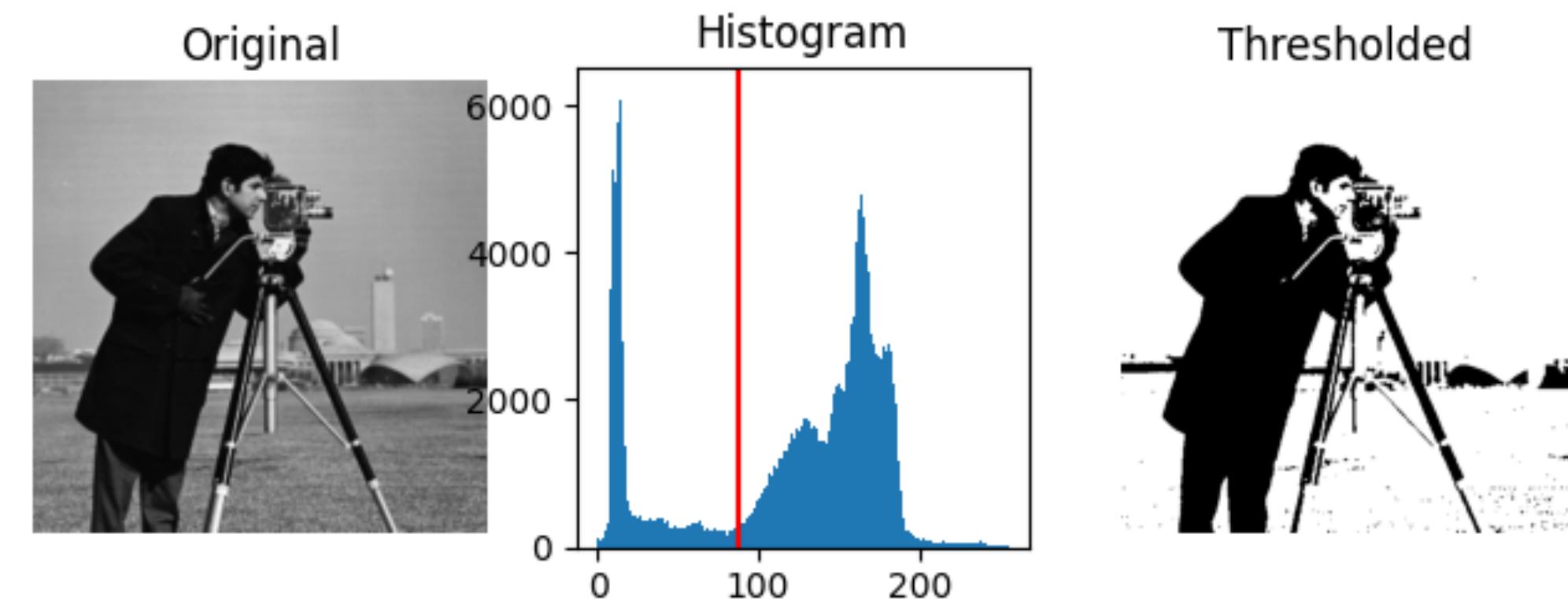
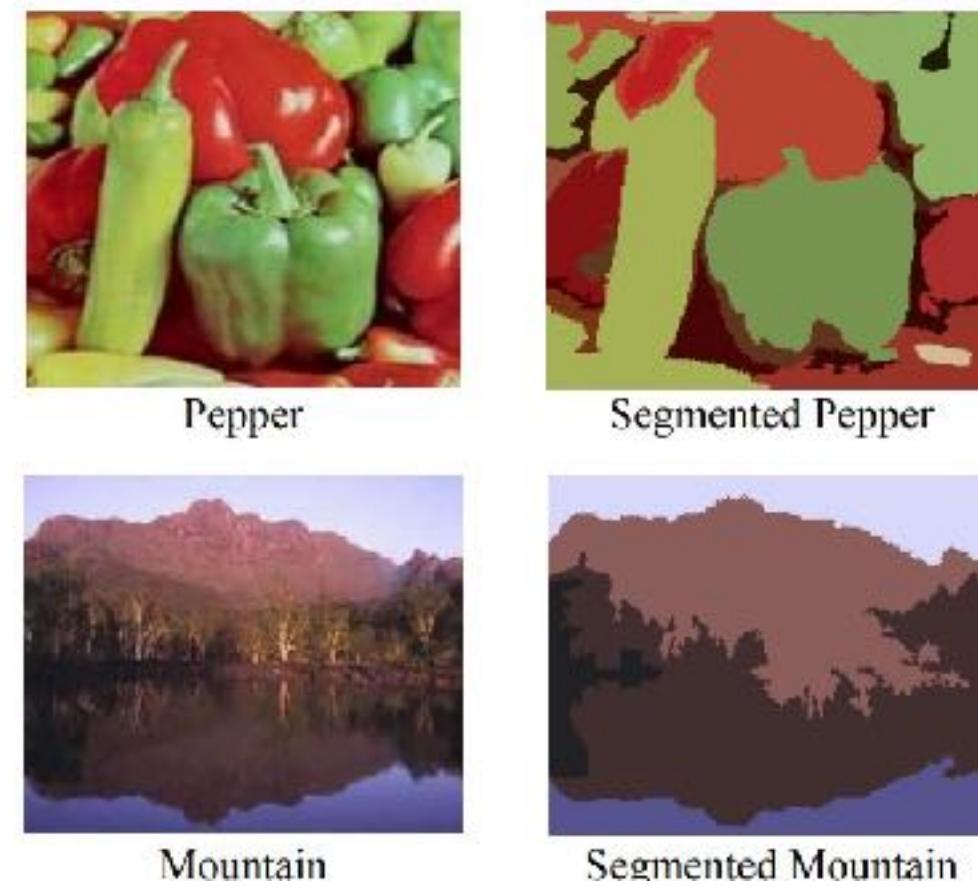
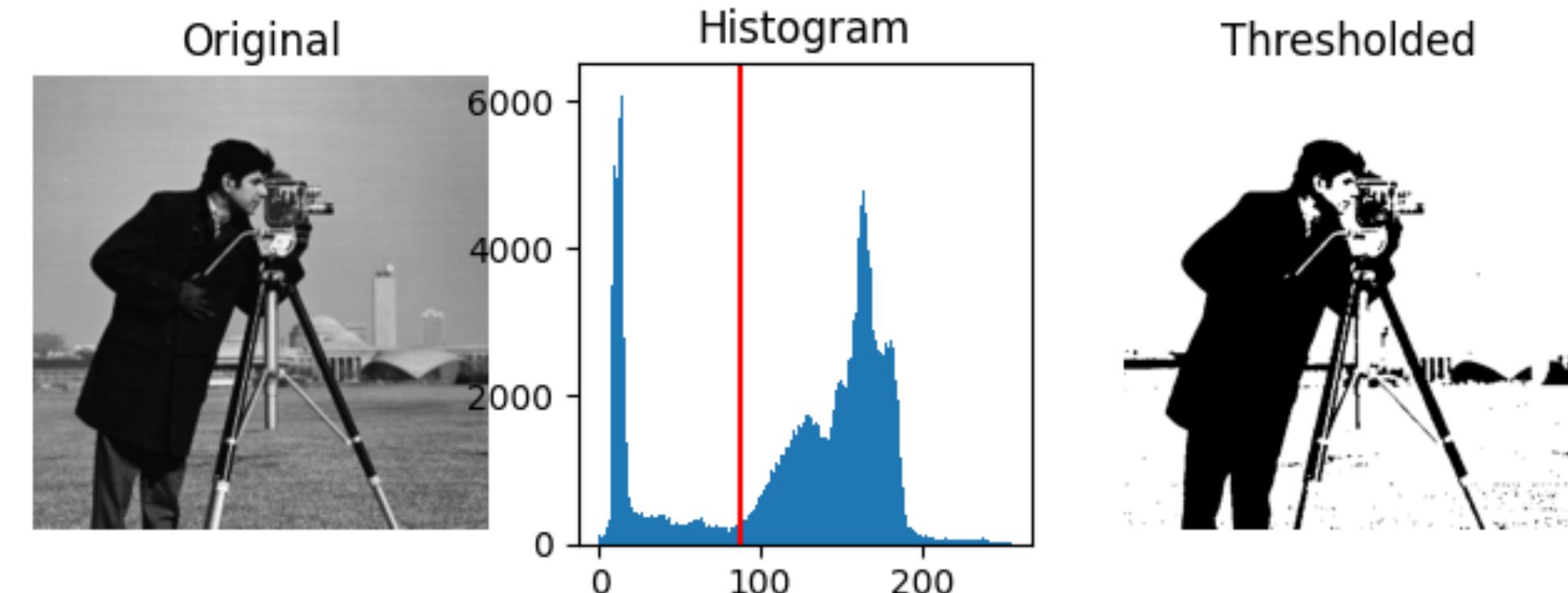


Image Segmentation

Segmentation



Thresholding



Connected components

Two 8x8 binary matrices representing connected components in a segmented image. Matrix (a) shows four components labeled 1, 2, 3, and 4. Matrix (b) shows five components labeled 1 through 5. In both cases, components are labeled with their respective numbers and are enclosed in colored boxes (white, blue, red, green).

0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	0
1	1	1	0	0	1	0	0
1	1	0	0	0	1	0	0
0	0	0	1	0	1	0	0
0	0	1	1	0	0	0	0
0	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0

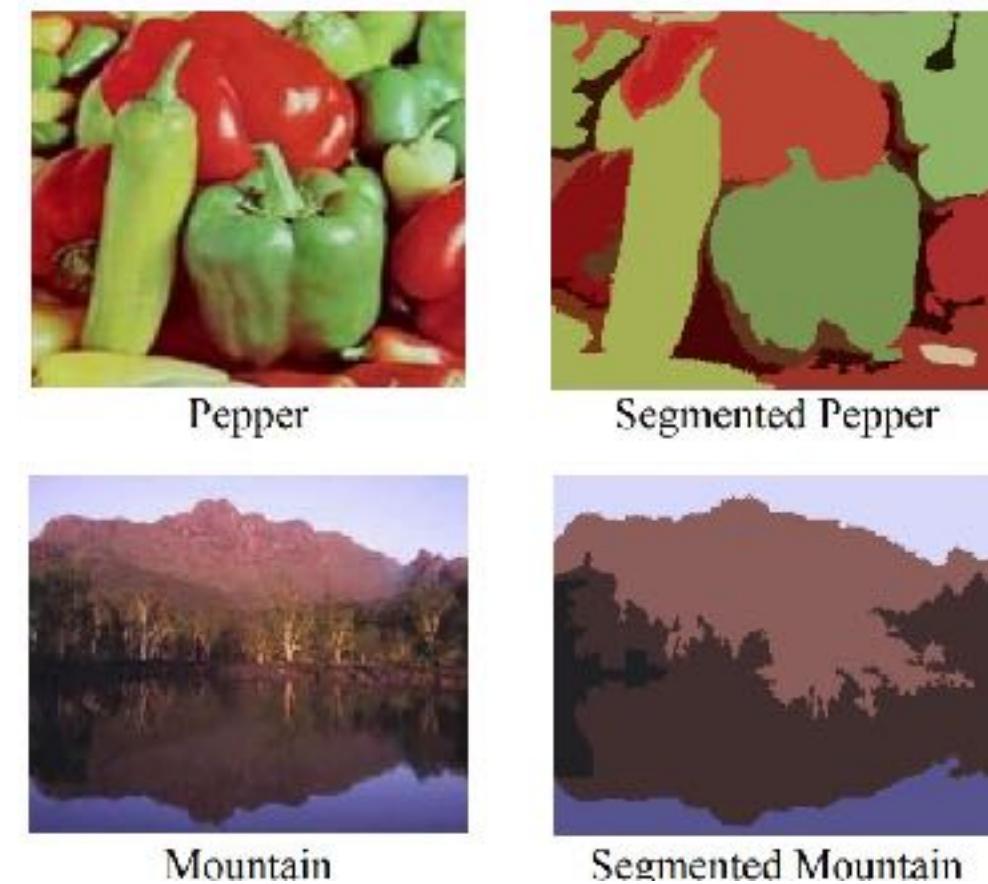
(a)

0	0	0	0	0	0	0	0
1	0	0	0	2	2	2	0
1	1	1	0	0	2	0	0
1	1	0	0	0	2	0	0
0	0	0	3	0	2	0	0
0	0	3	3	0	0	0	0
0	0	0	0	0	4	4	0
0	0	0	0	0	0	0	0

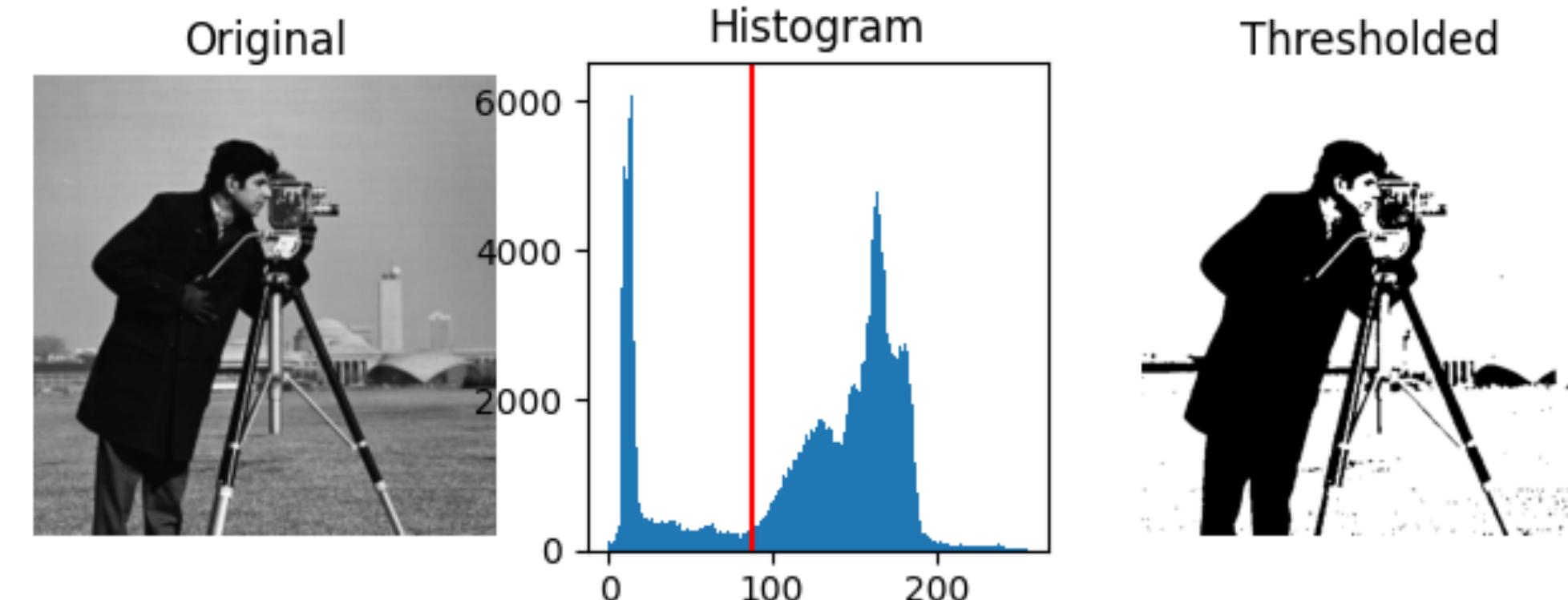
(b)

Image Segmentation

Segmentation



Thresholding



Connected components

Two 8x8 matrices representing connected components. Matrix (a) shows components labeled 1 through 5. Matrix (b) shows components labeled 0 through 4.

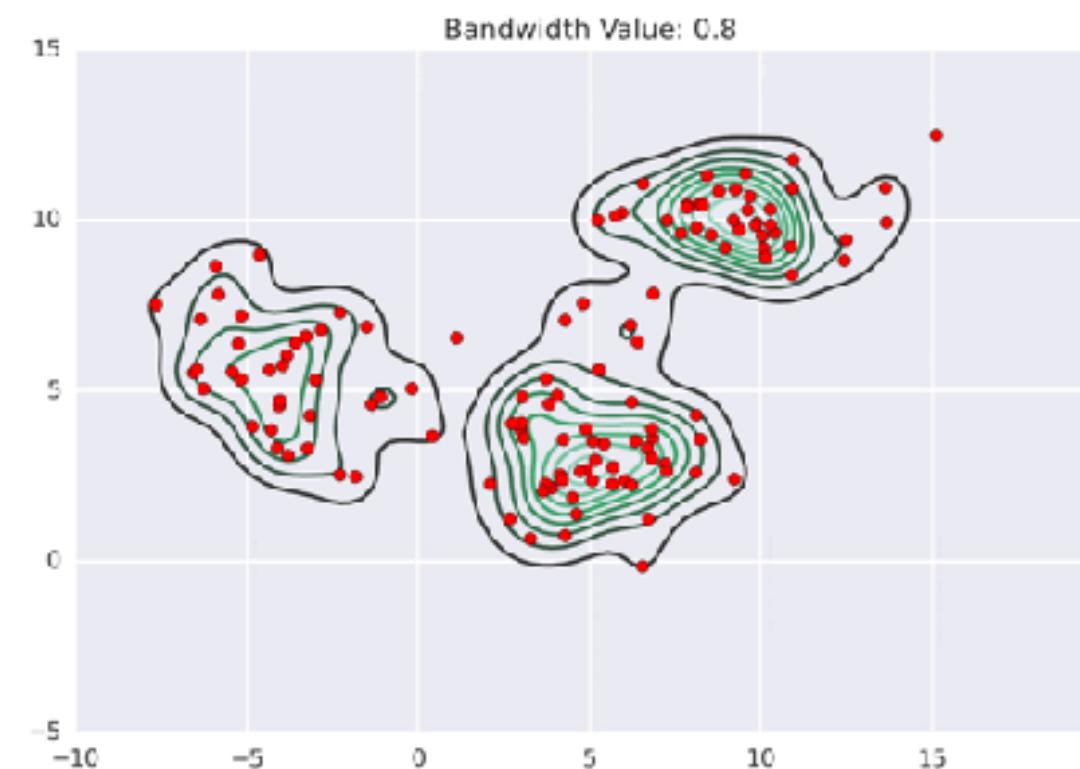
0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	
1	1	1	0	0	1	0	
1	1	0	0	0	1	0	
0	0	0	1	0	1	0	
0	0	1	1	0	0	0	
0	0	0	0	0	1	1	
0	0	0	0	0	0	0	0

(a)

0	0	0	0	0	0	0	0
1	0	0	0	2	2	2	
1	1	1	0	0	2	0	
1	1	0	0	0	2	0	
0	0	0	3	0	2	0	
0	0	3	3	0	0	0	
0	0	0	0	0	4	4	
0	0	0	0	0	0	0	0

(b)

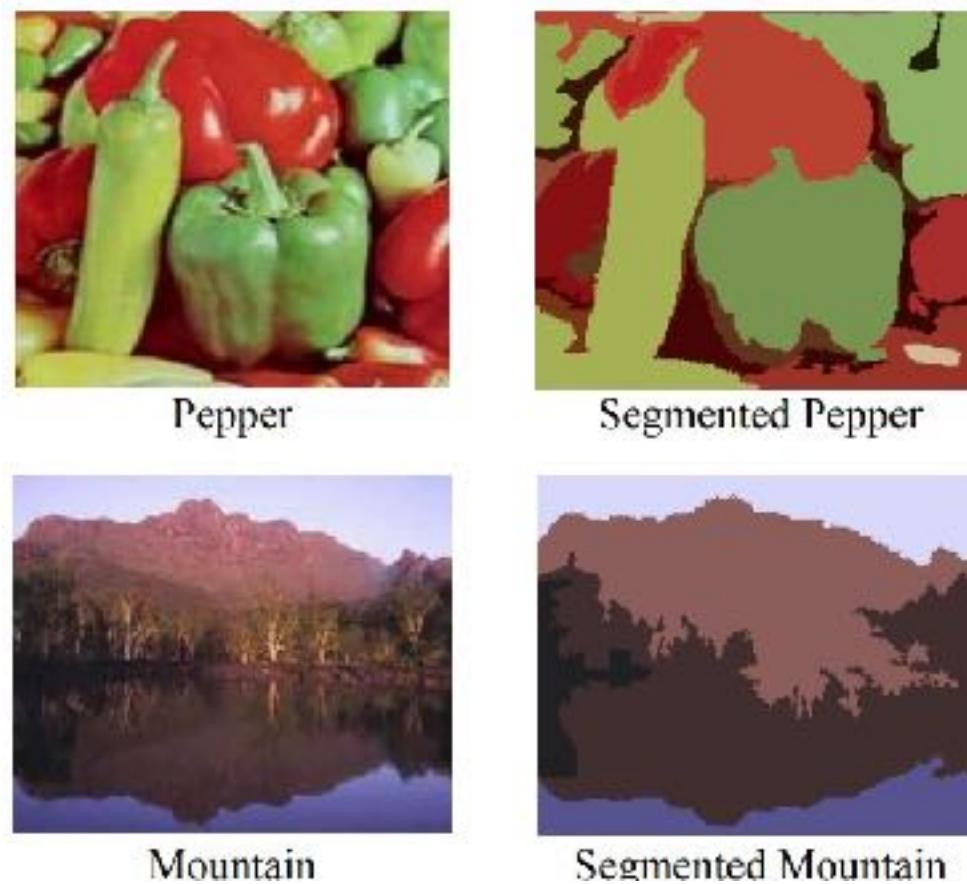
Clustering



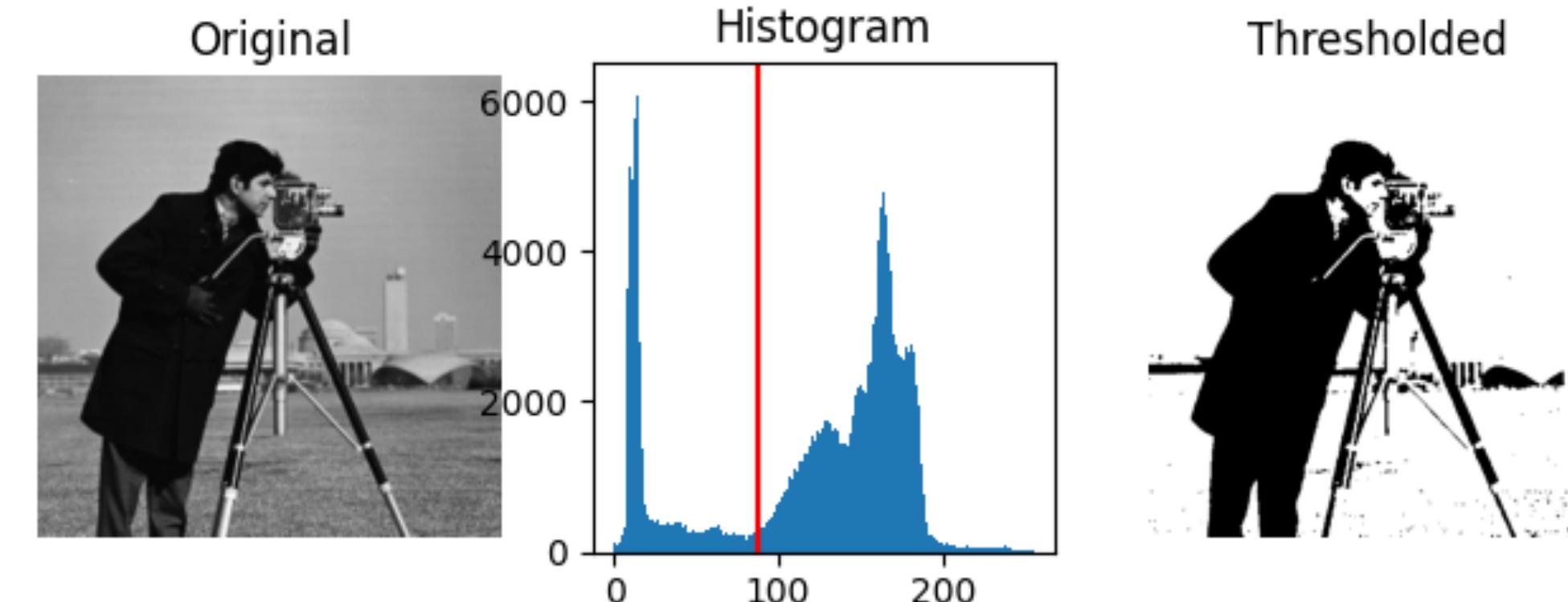
Introduction

Image Segmentation

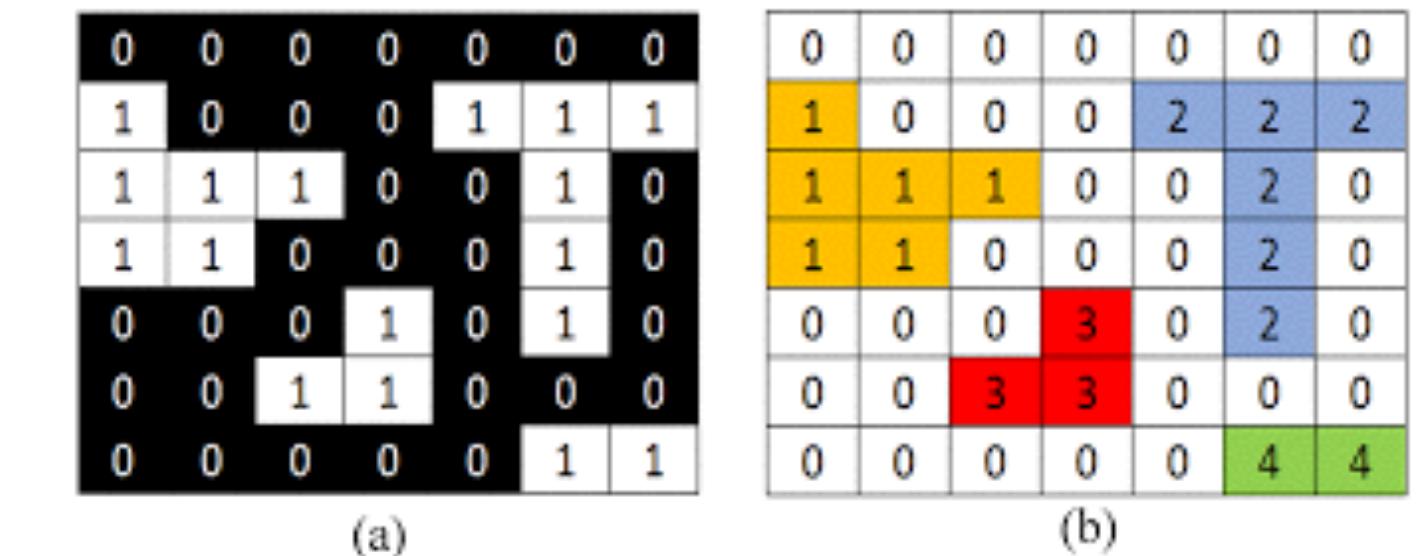
Segmentation



Thresholding



Connected components



Two 8x8 binary matrices representing connected components:

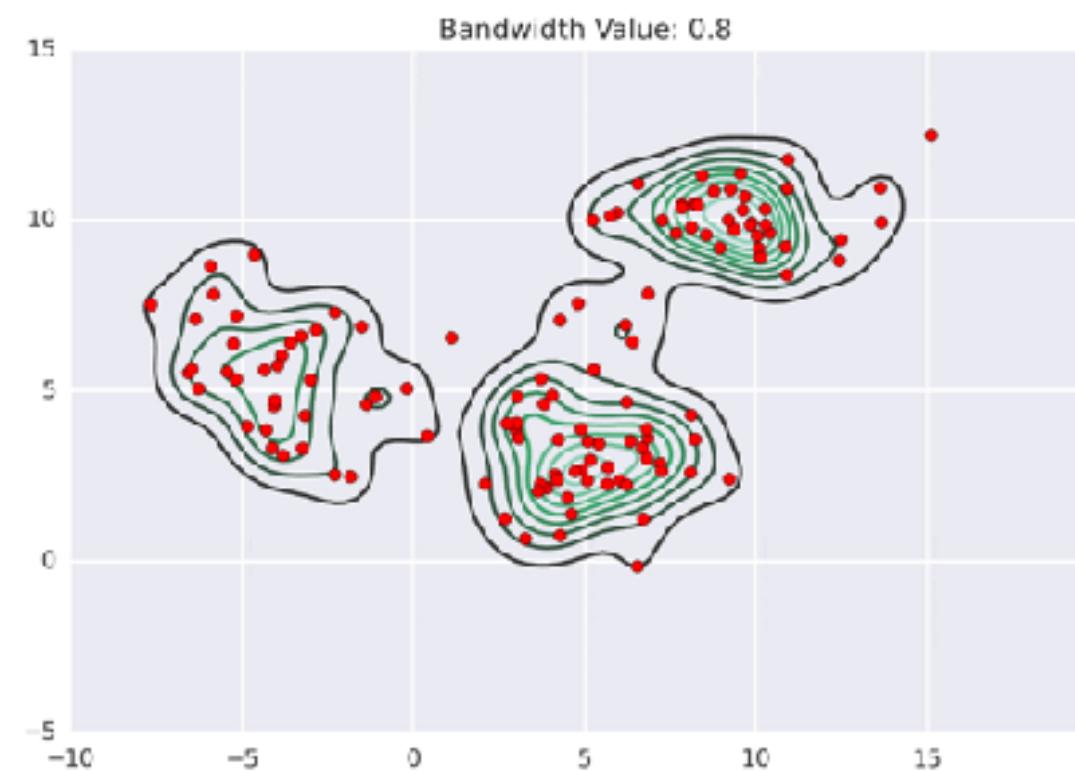
0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	
1	1	1	0	0	1	0	
1	1	0	0	0	1	0	
0	0	0	1	0	1	0	
0	0	1	1	0	0	0	
0	0	0	0	0	1	1	

(a)

0	0	0	0	0	0	0	0
1	0	0	0	2	2	2	
1	1	1	0	0	2	0	
1	1	0	0	0	2	0	
0	0	0	3	0	2	0	
0	0	3	3	0	0	0	
0	0	0	0	0	4	4	

(b)

Clustering



Graph-based methods

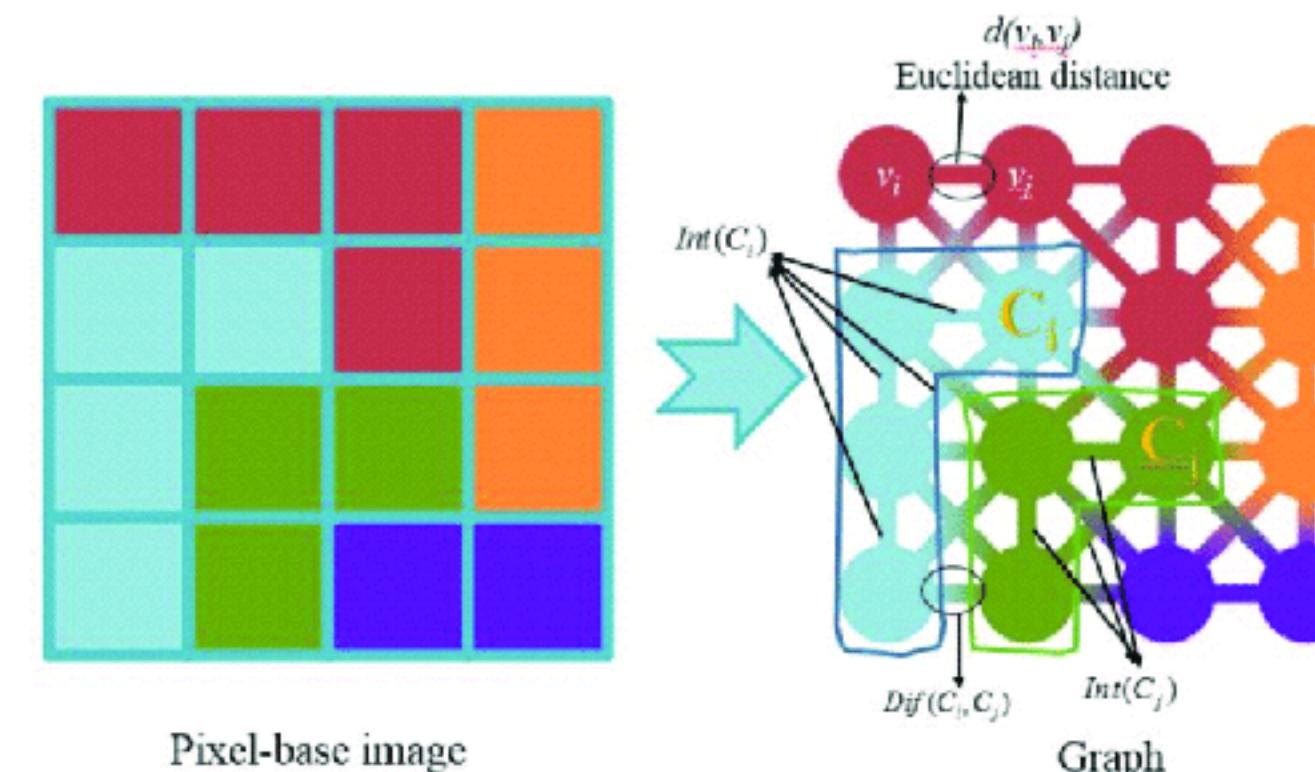
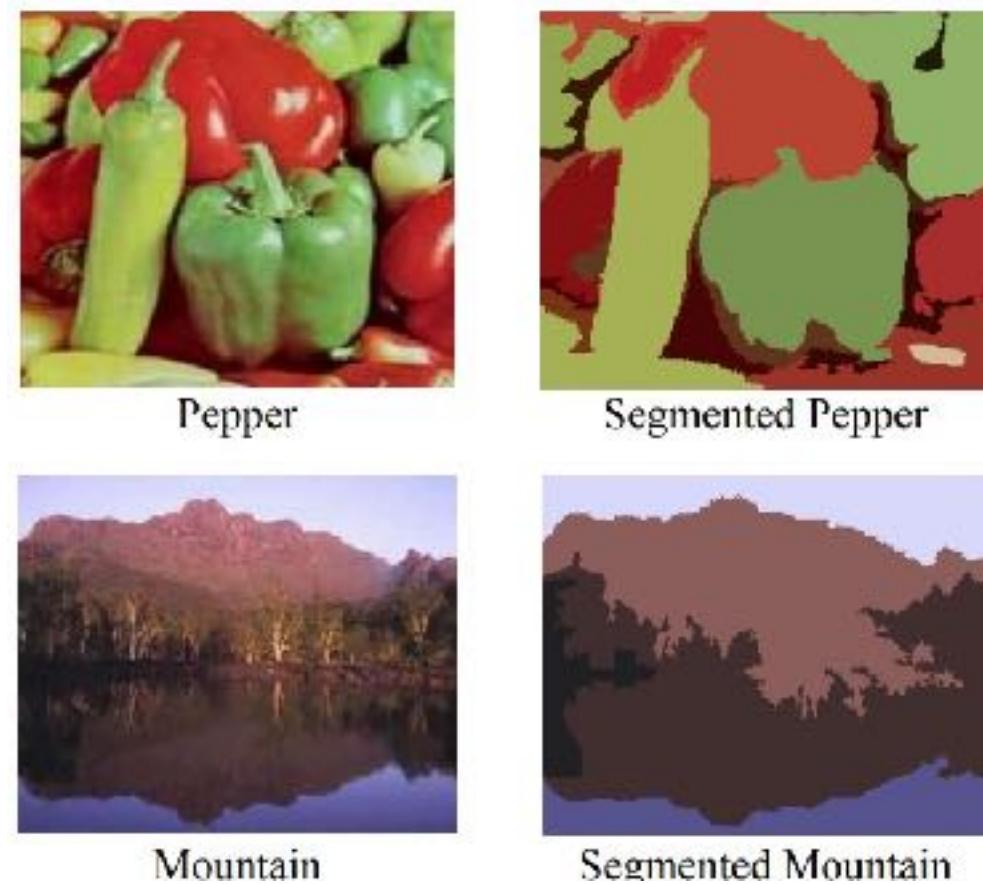
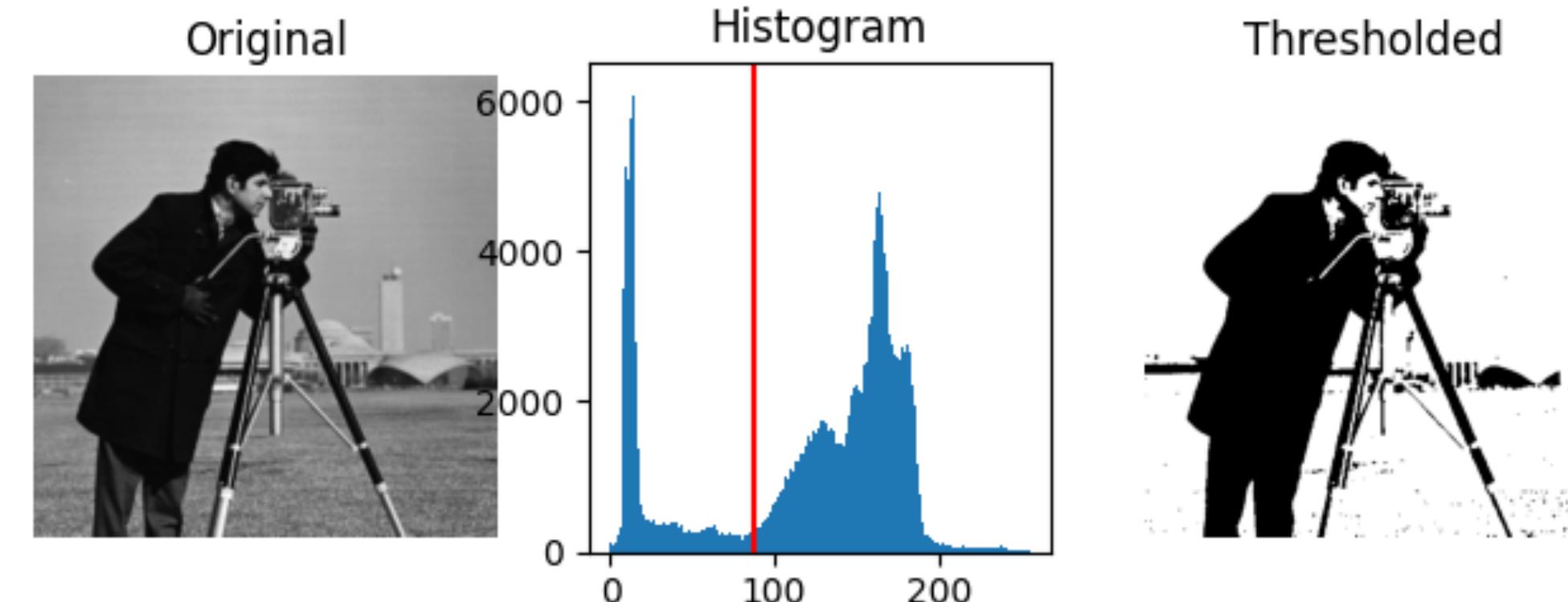


Image Segmentation

Segmentation



Thresholding



Connected components

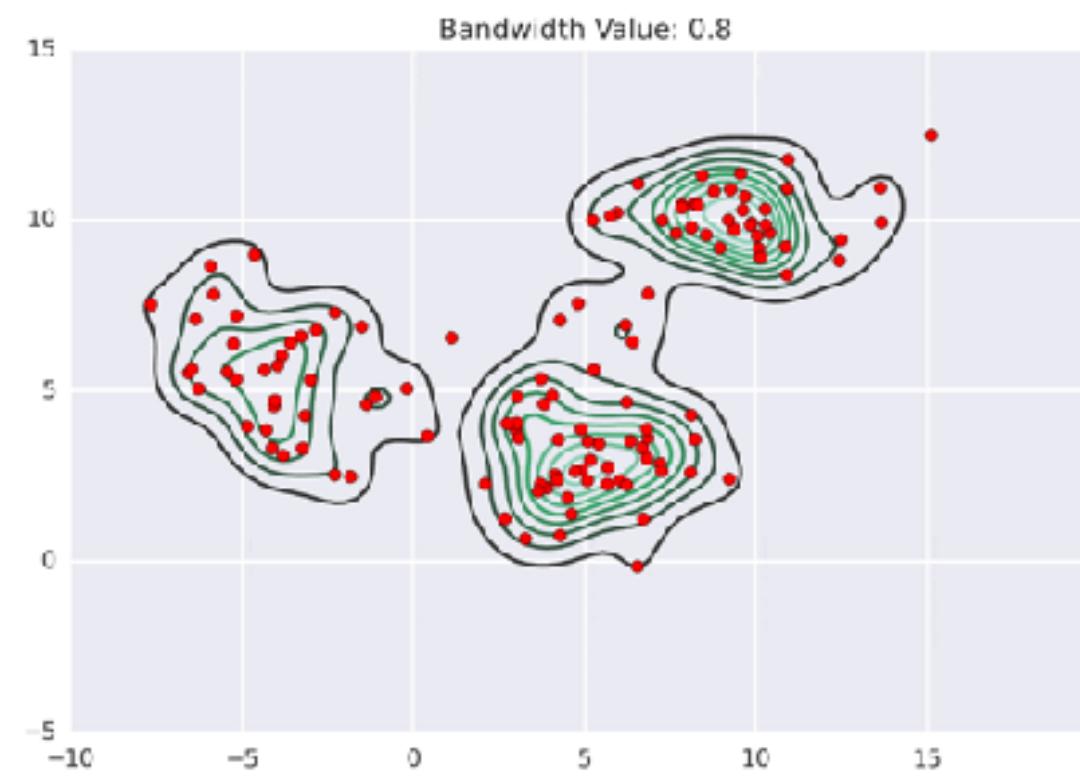
(a)

0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	
1	1	1	1	0	0	1	0
1	1	0	0	0	0	1	0
0	0	0	1	0	1	0	
0	0	1	1	0	0	0	
0	0	0	0	0	1	1	

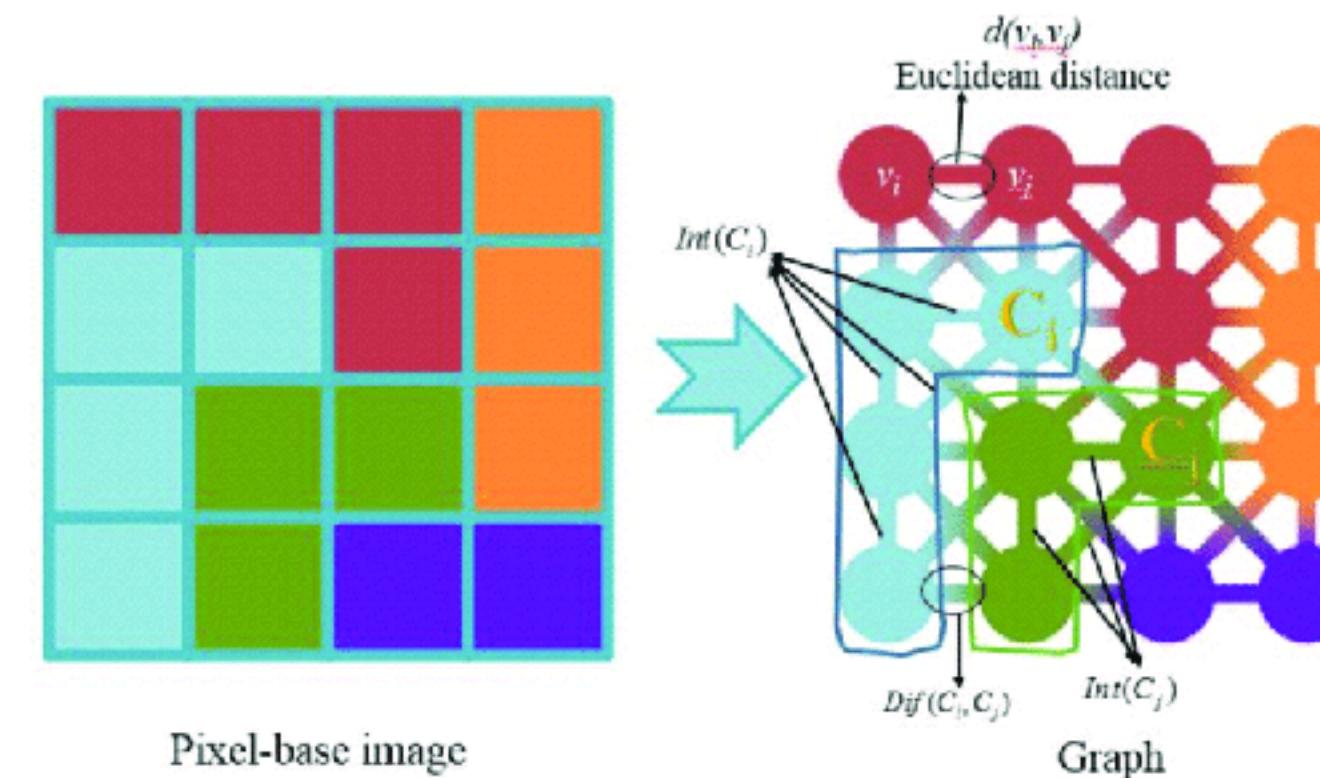
(b)

0	0	0	0	0	0	0	0
1	0	0	0	2	2	2	
1	1	1	1	0	0	2	0
1	1	0	0	0	0	2	0
0	0	0	3	0	2	0	
0	0	3	3	0	0	0	
0	0	0	0	0	4	4	

Clustering



Graph-based methods



Evaluation

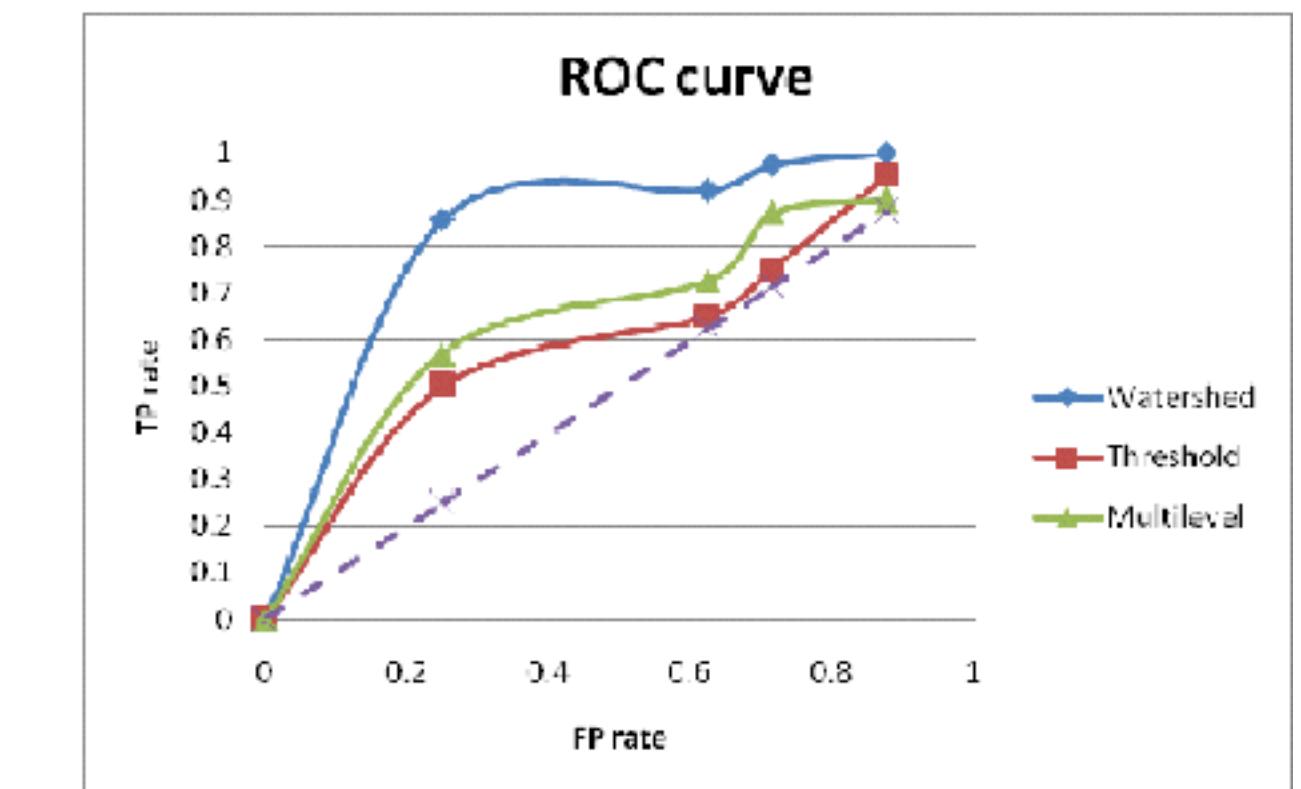


Image Transformation

Image Transformation

Linear transformations

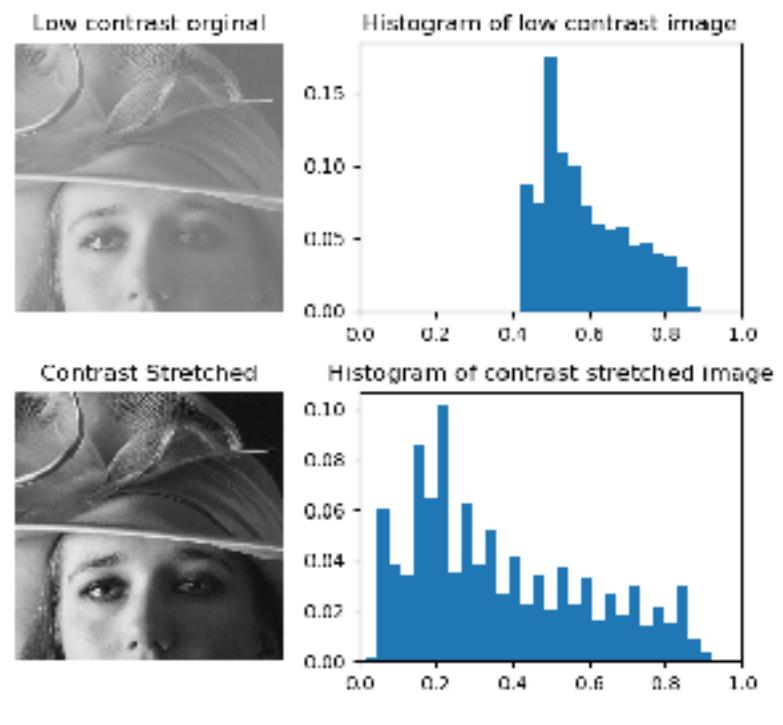
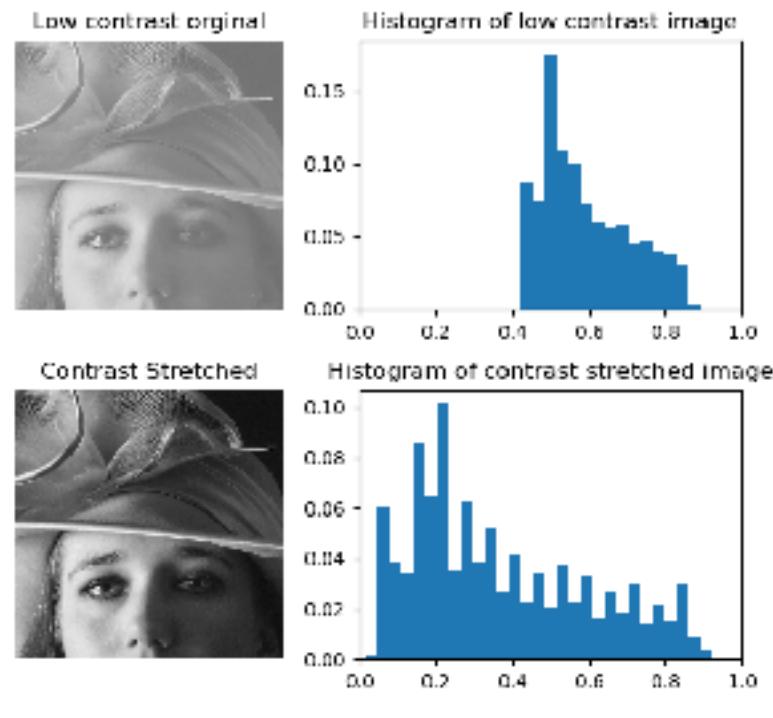


Image Transformation

Linear transformations



Non-linear transformations

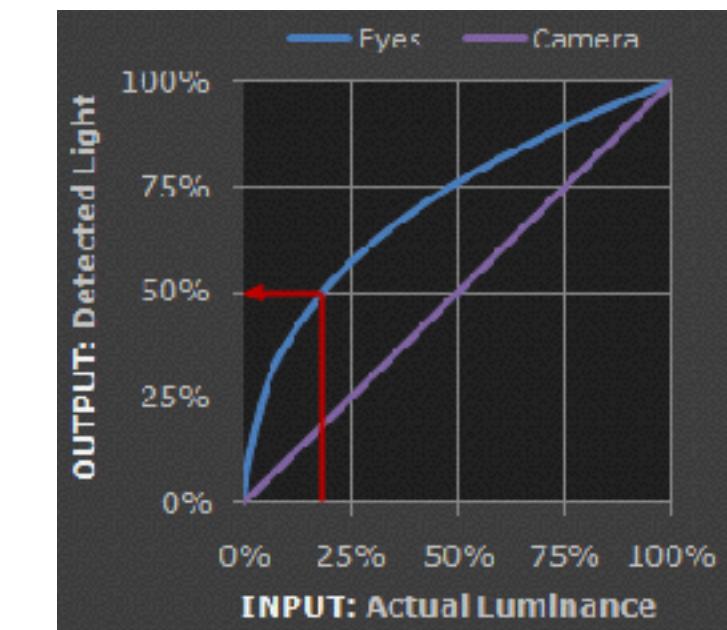
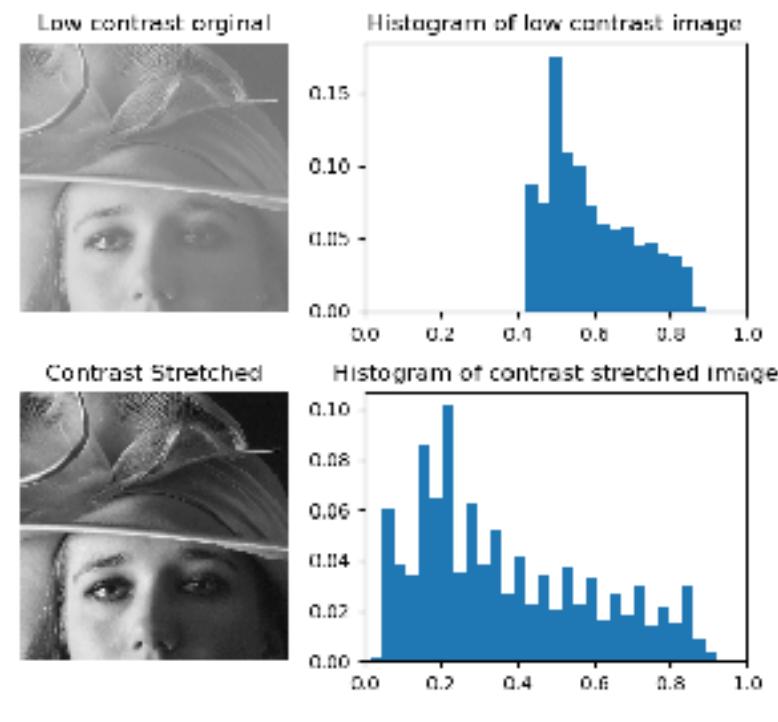
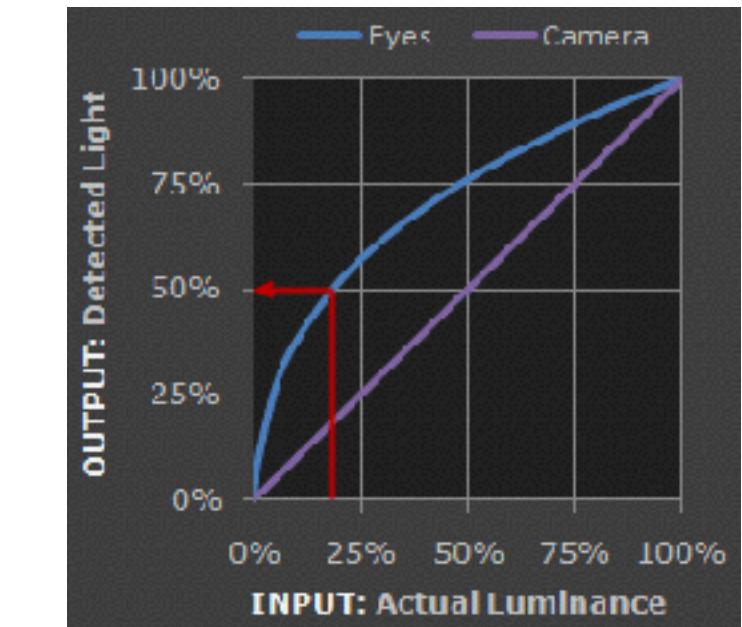


Image Transformation

Linear transformations



Non-linear transformations



Histogram equalization

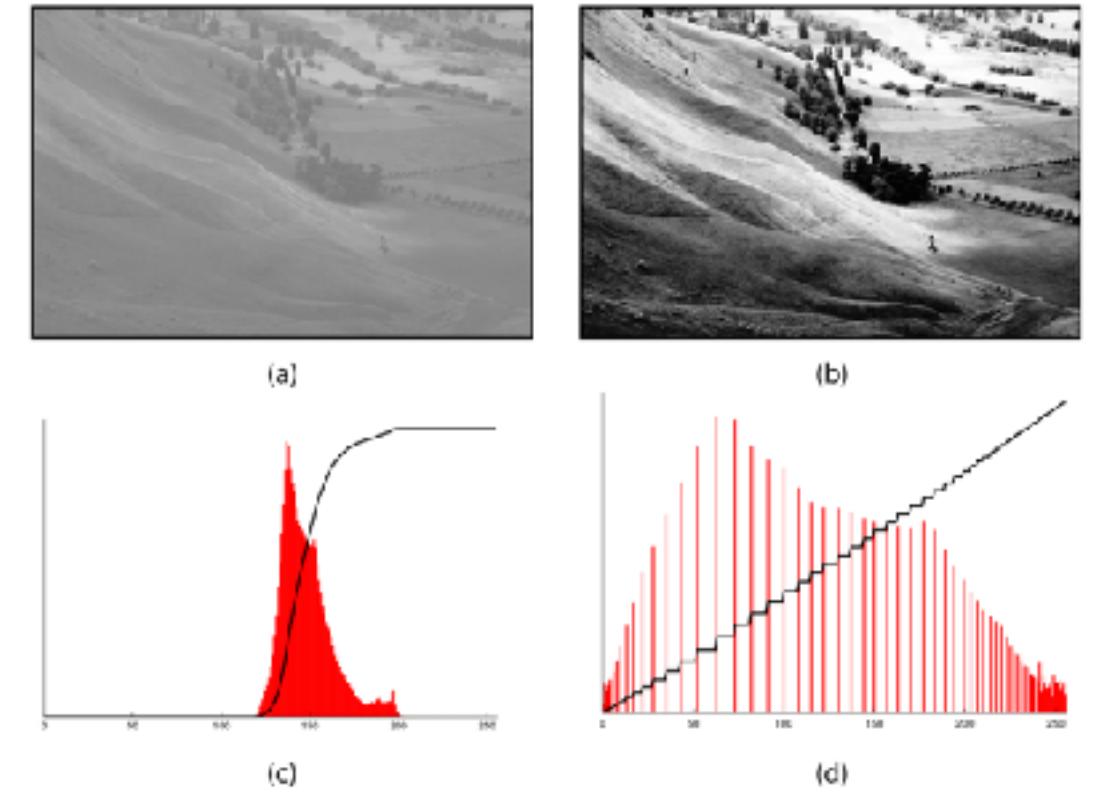
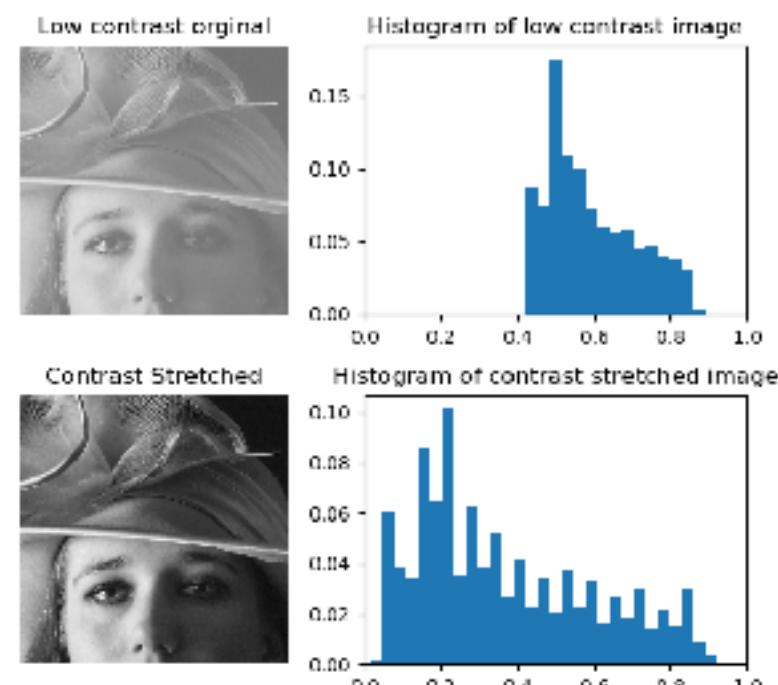
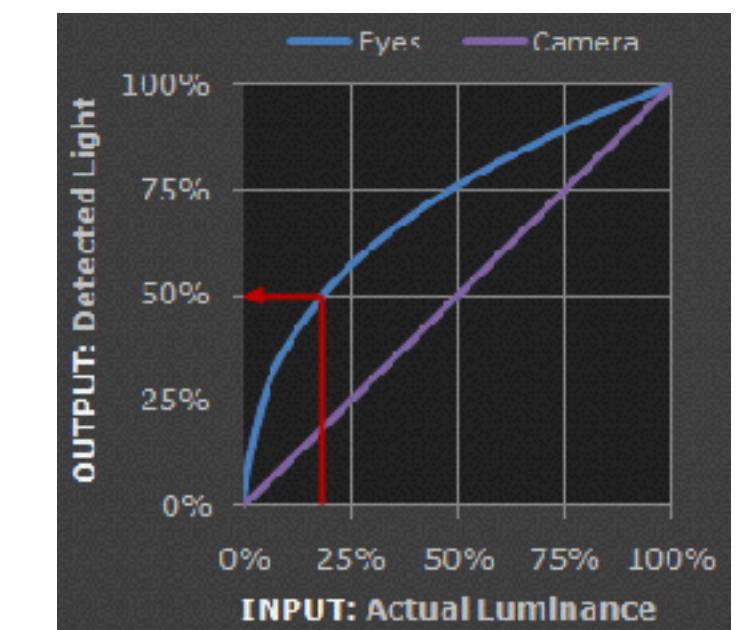


Image Transformation

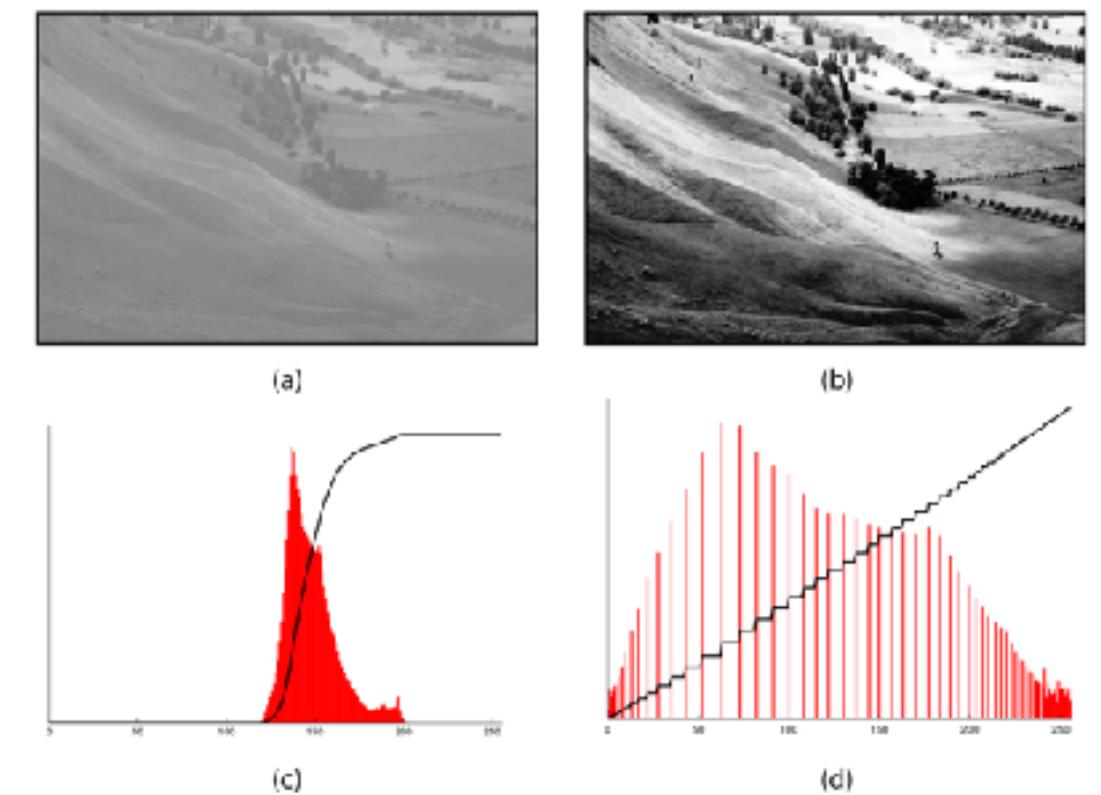
Linear transformations



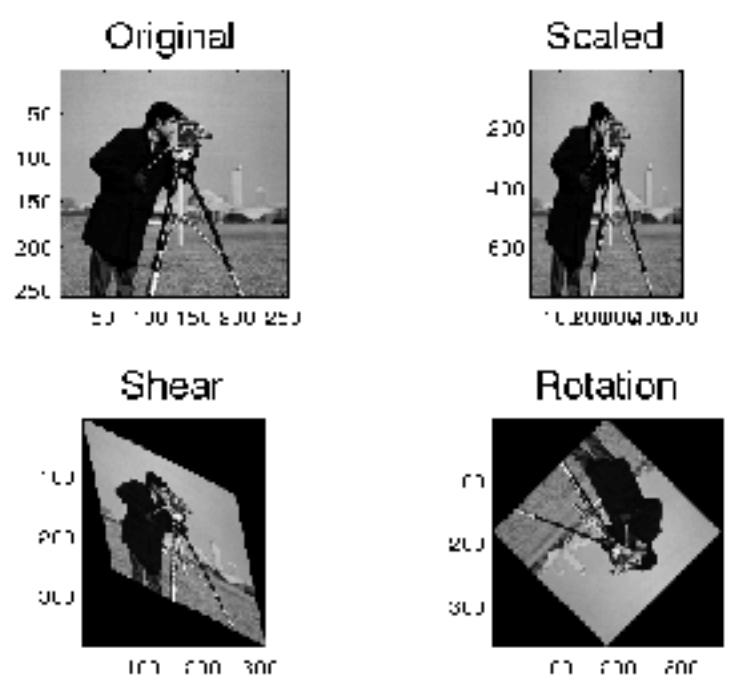
Non-linear transformations



Histogram equalization



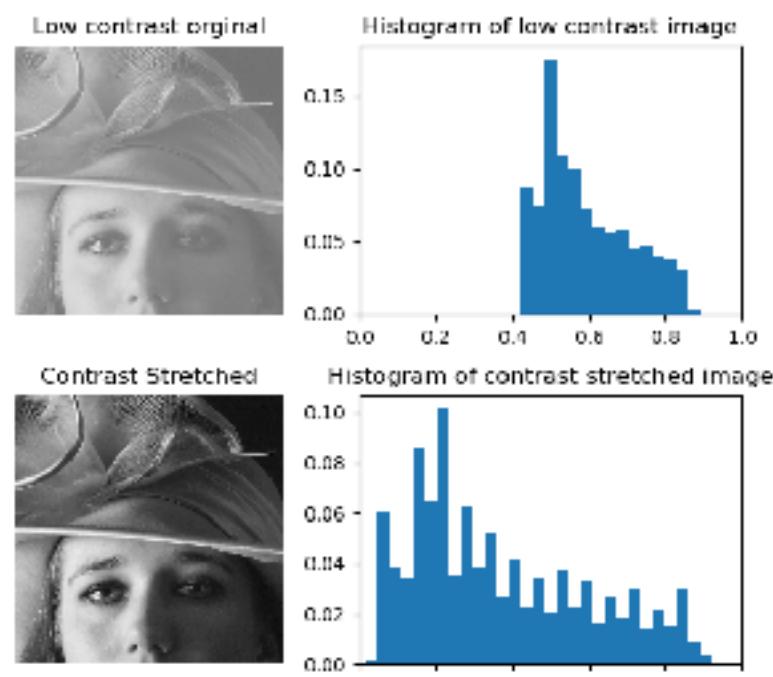
Affine transformations



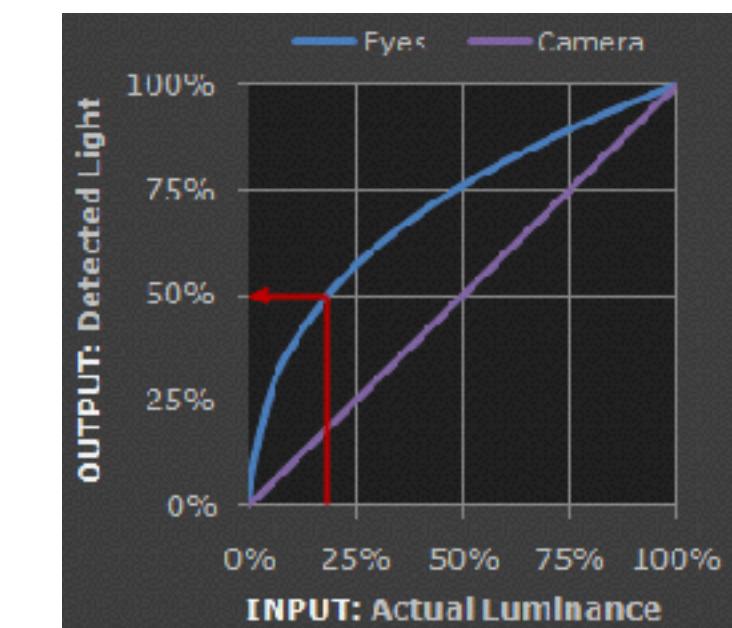
Introduction

Image Transformation

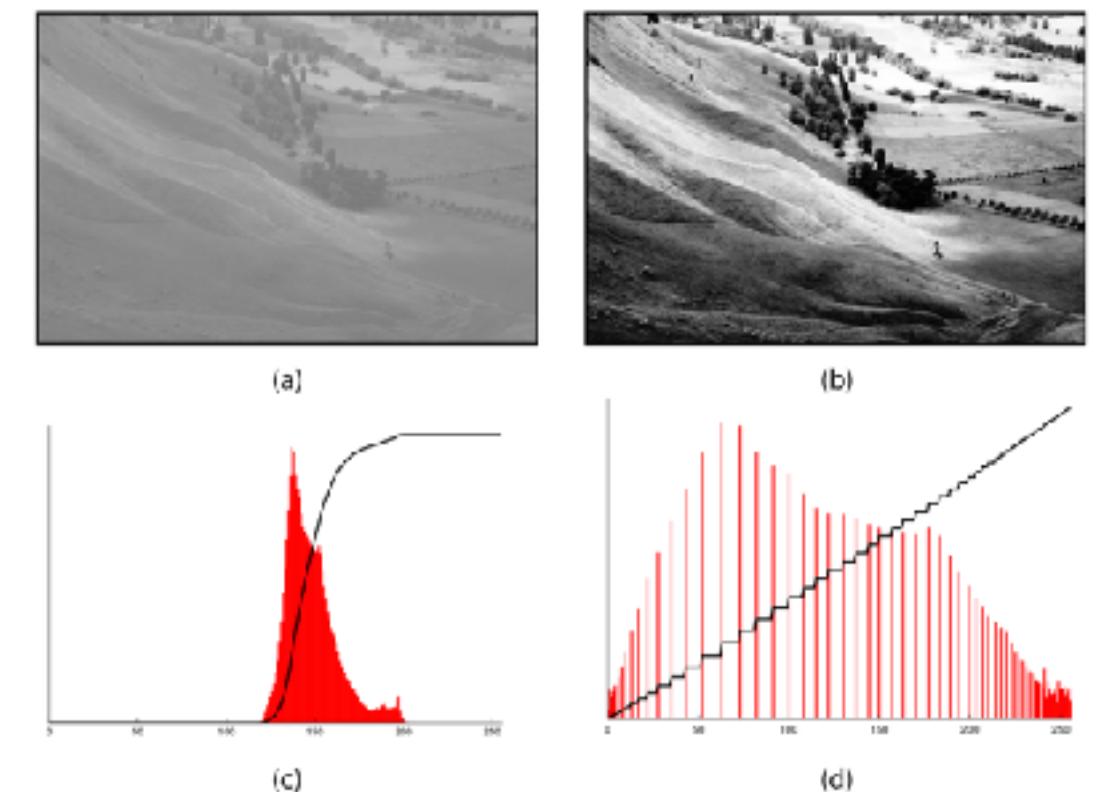
Linear transformations



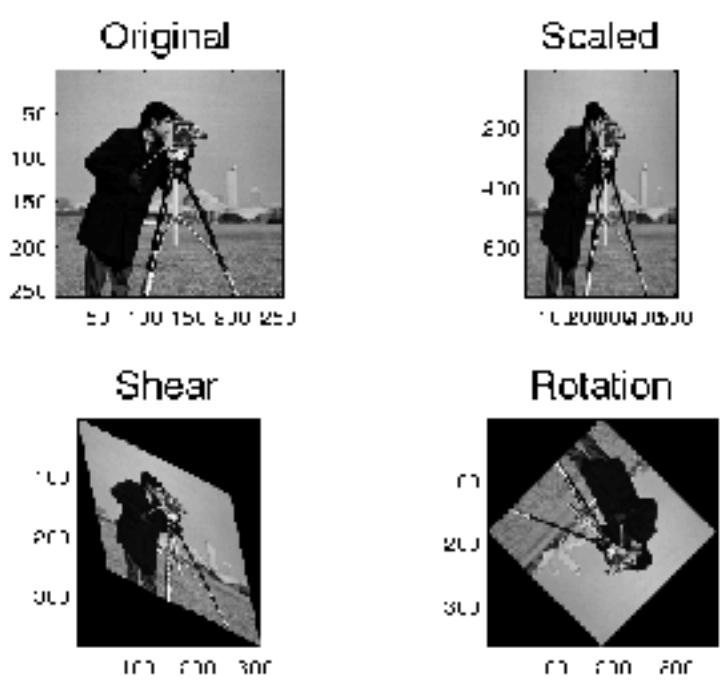
Non-linear transformations



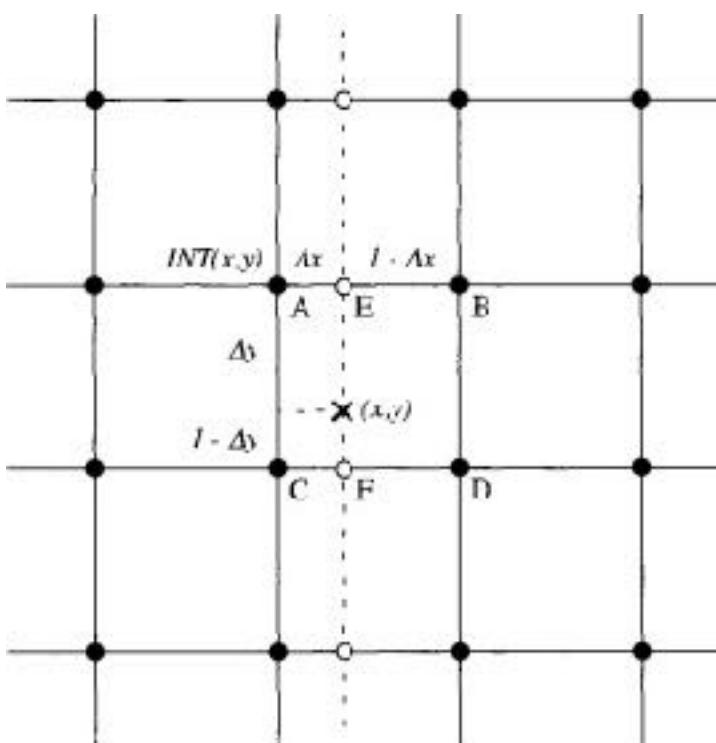
Histogram equalization



Affine transformations



Interpolation



bilinear resampling:

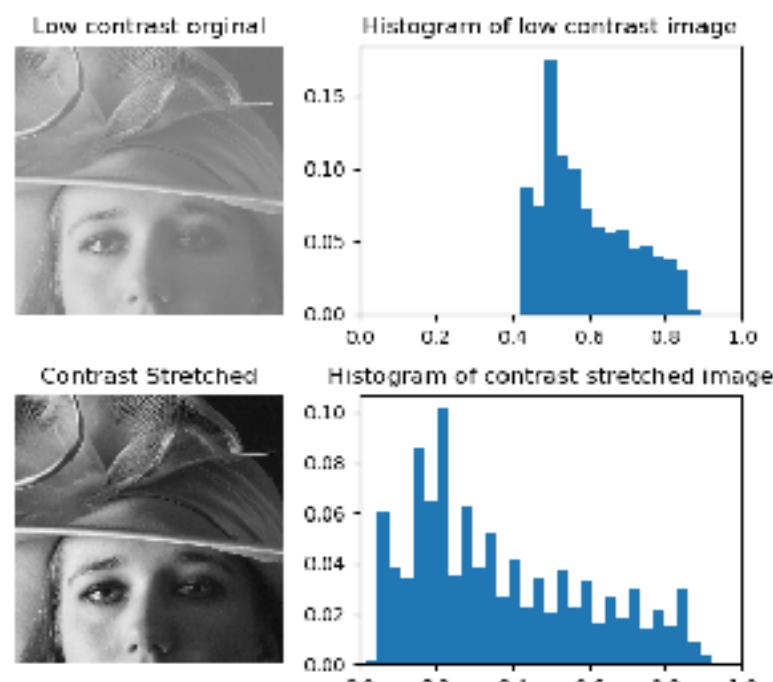
$$DN_E = \Delta x DN_B + (1 - \Delta x) DN_A$$

$$DN_F = \Delta y DN_D + (1 - \Delta y) DN_C$$

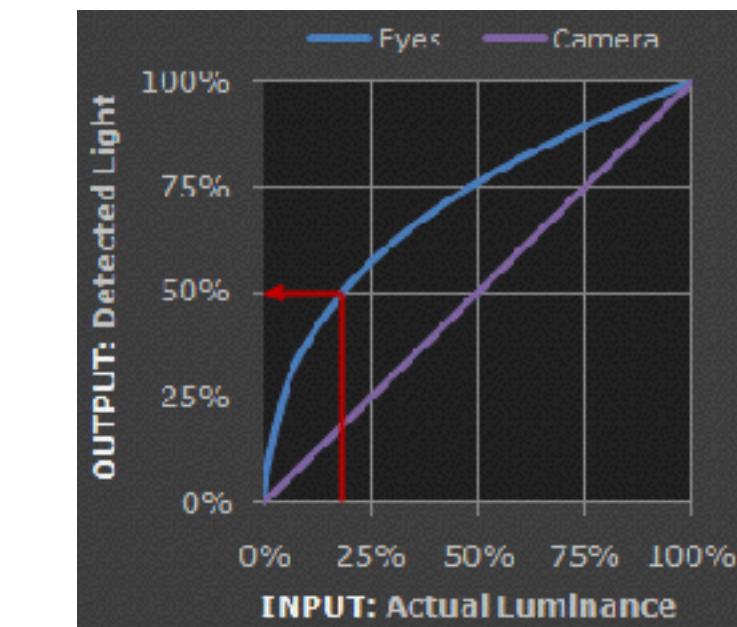
$$DN(x, y) = \Delta y DN_F + (1 - \Delta y) DN_E$$

Image Transformation

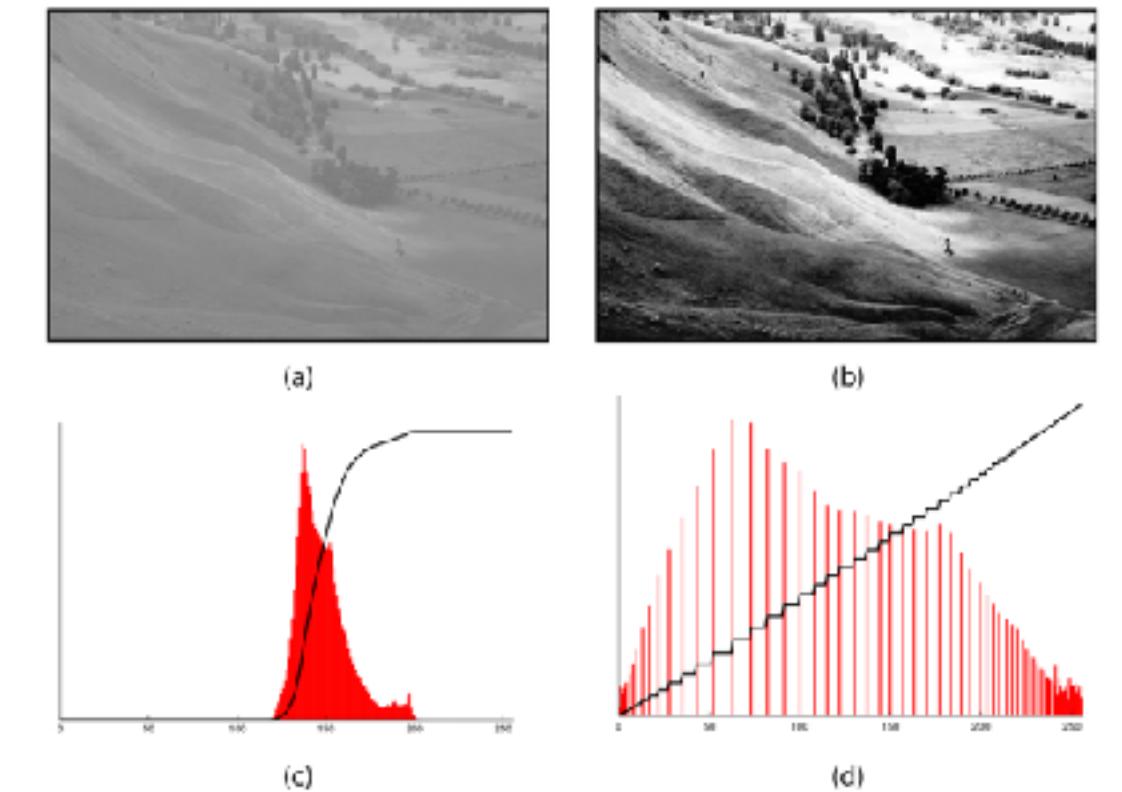
Linear transformations



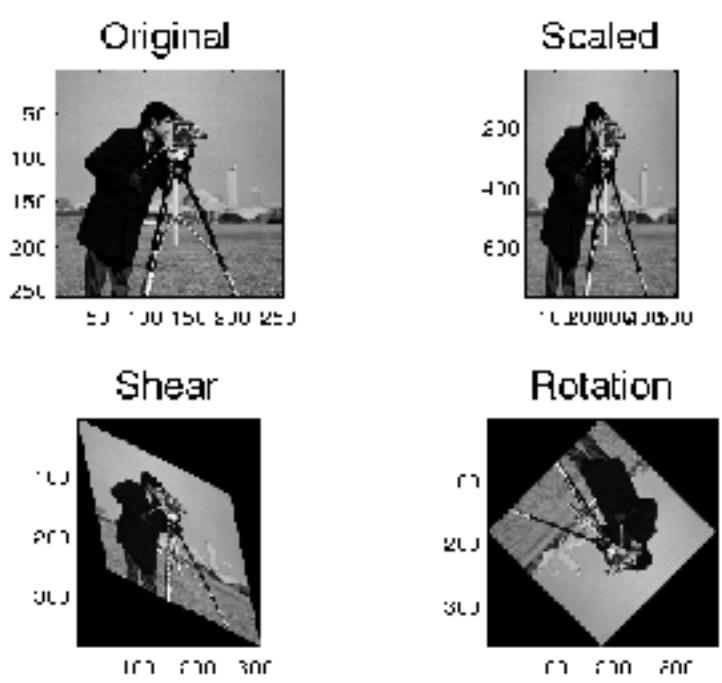
Non-linear transformations



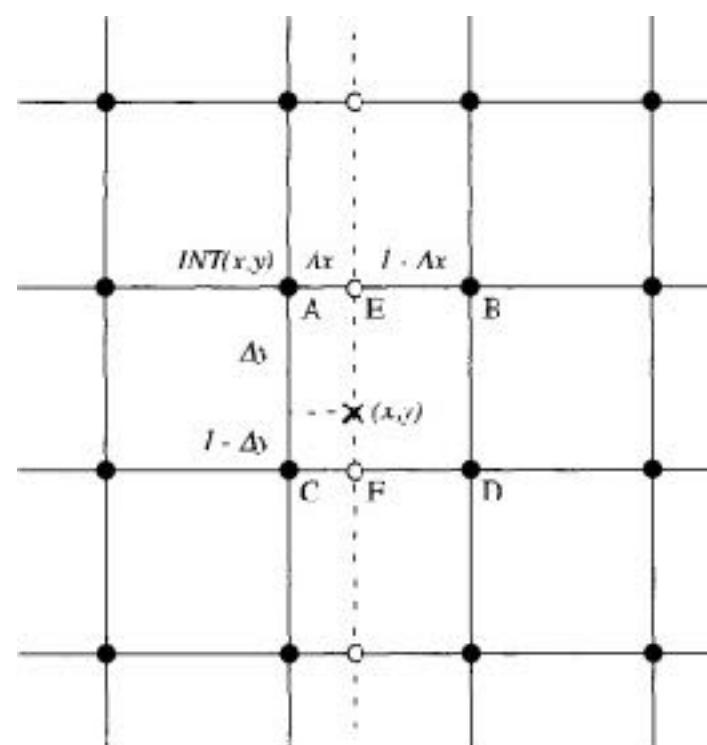
Histogram equalization



Affine transformations



Interpolation



bilinear resampling:

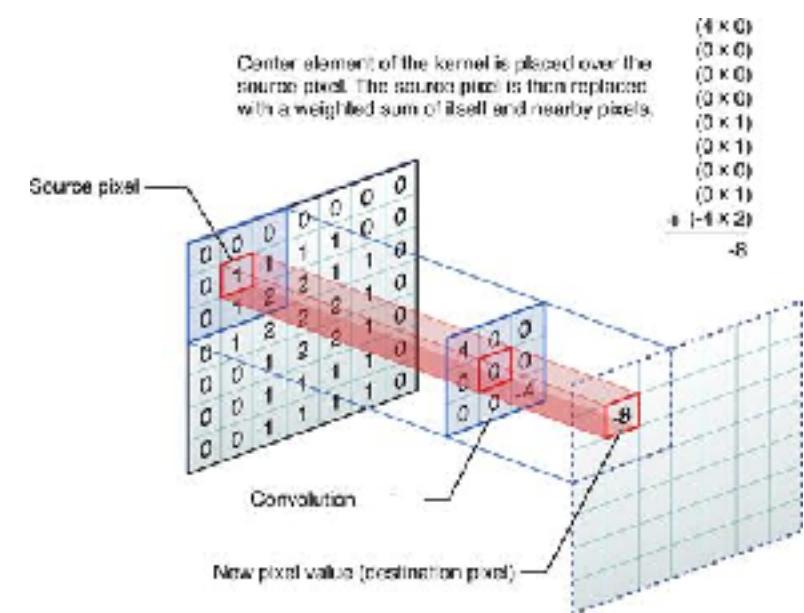
$$DN_E = \Delta x DN_B + (1 - \Delta x) DN_A$$
$$DN_F = \Delta x DN_D + (1 - \Delta x) DN_C$$
$$DN(x, y) = \Delta y DN_F + (1 - \Delta y) DN_E$$



Filtering in Spatial Domain

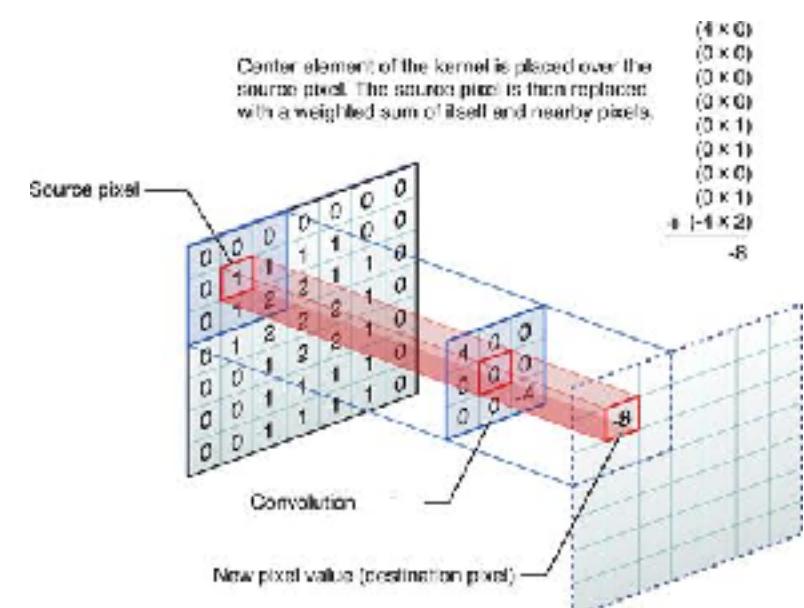
Filtering in Spatial Domain

Convolution filters

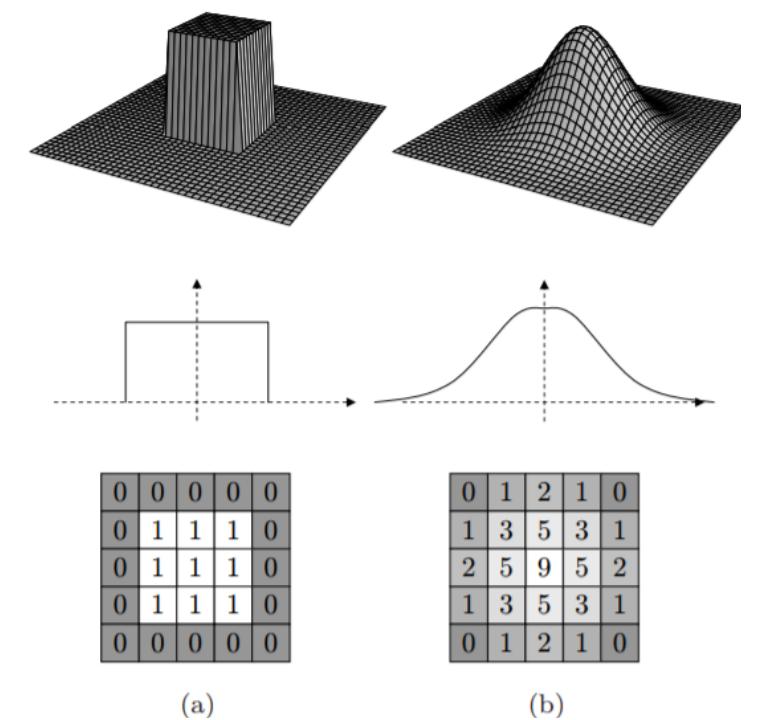
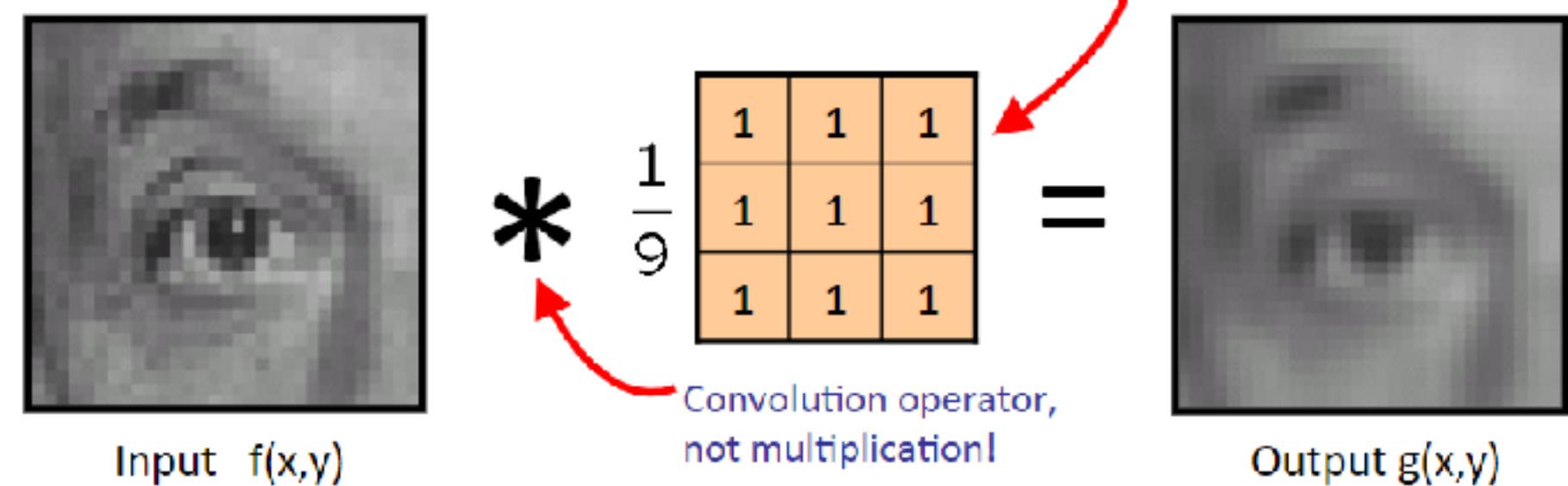


Filtering in Spatial Domain

Convolution filters

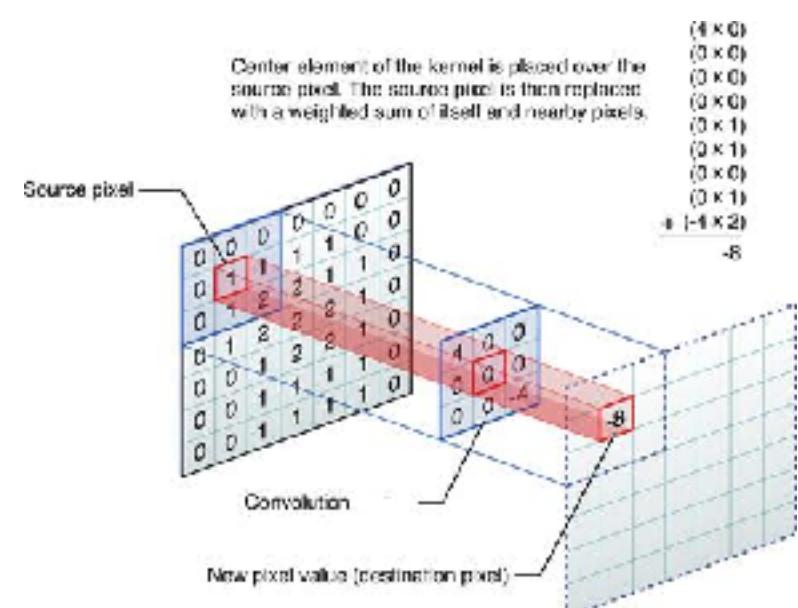


Smoothing filters

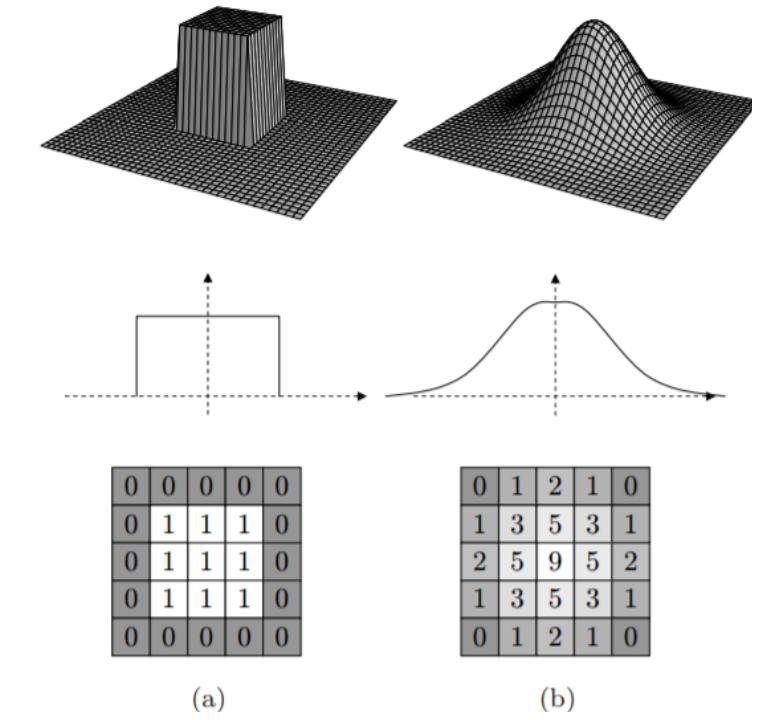
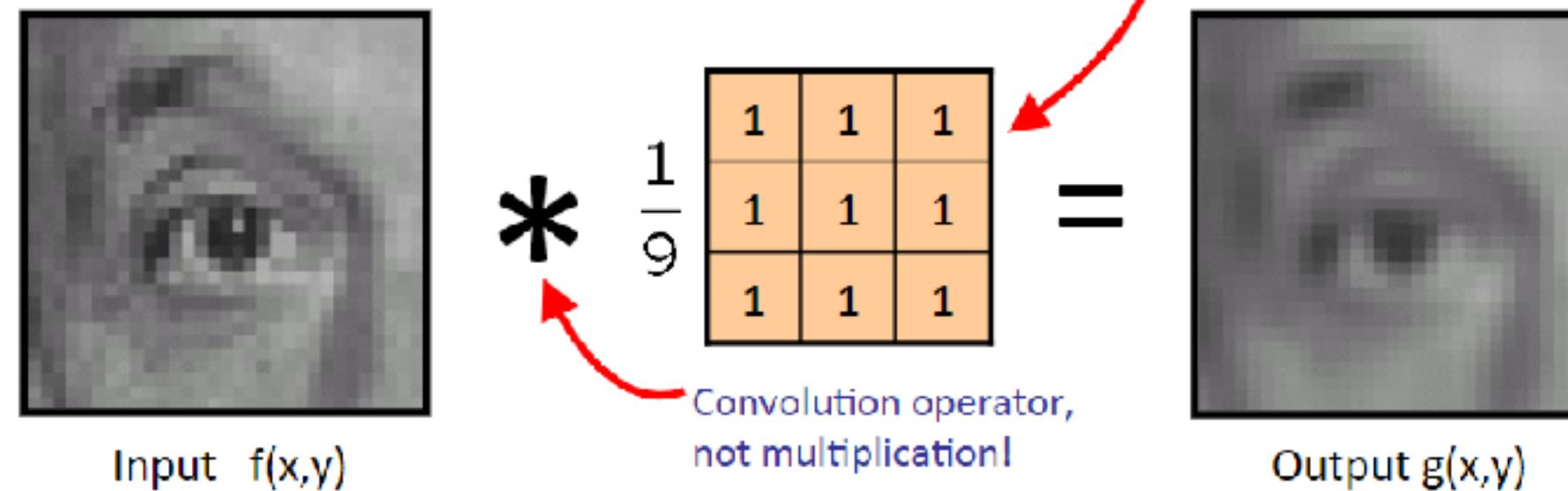


Filtering in Spatial Domain

Convolution filters



Smoothing filters



Derivative filters

-1	0	+1
-2	0	2
-1	0	+1

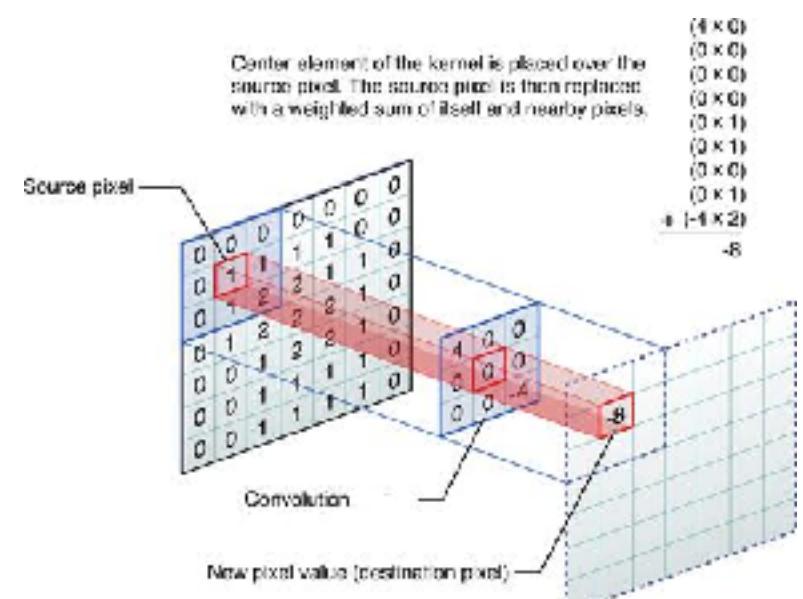
G_x

+1	+2	+1
0	0	0
-1	-2	-1

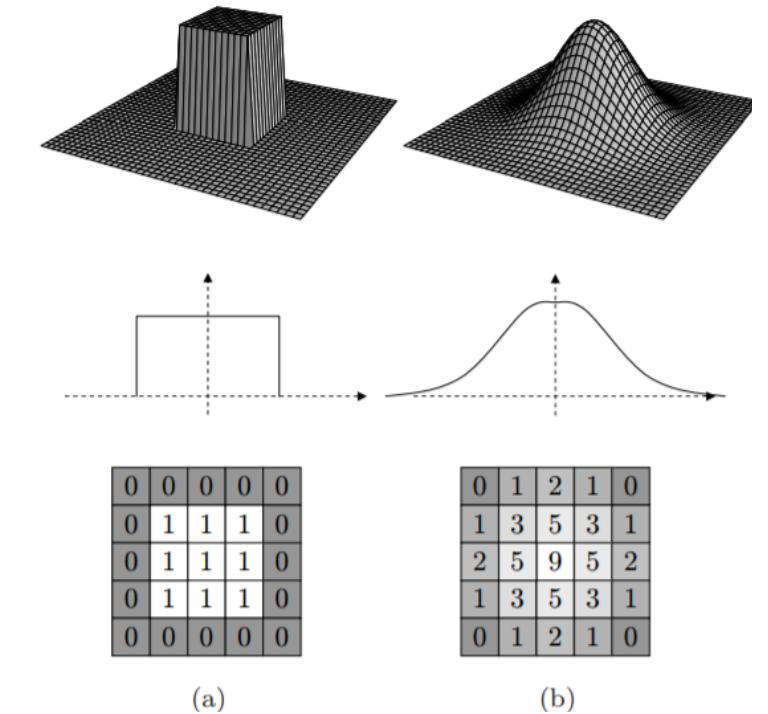
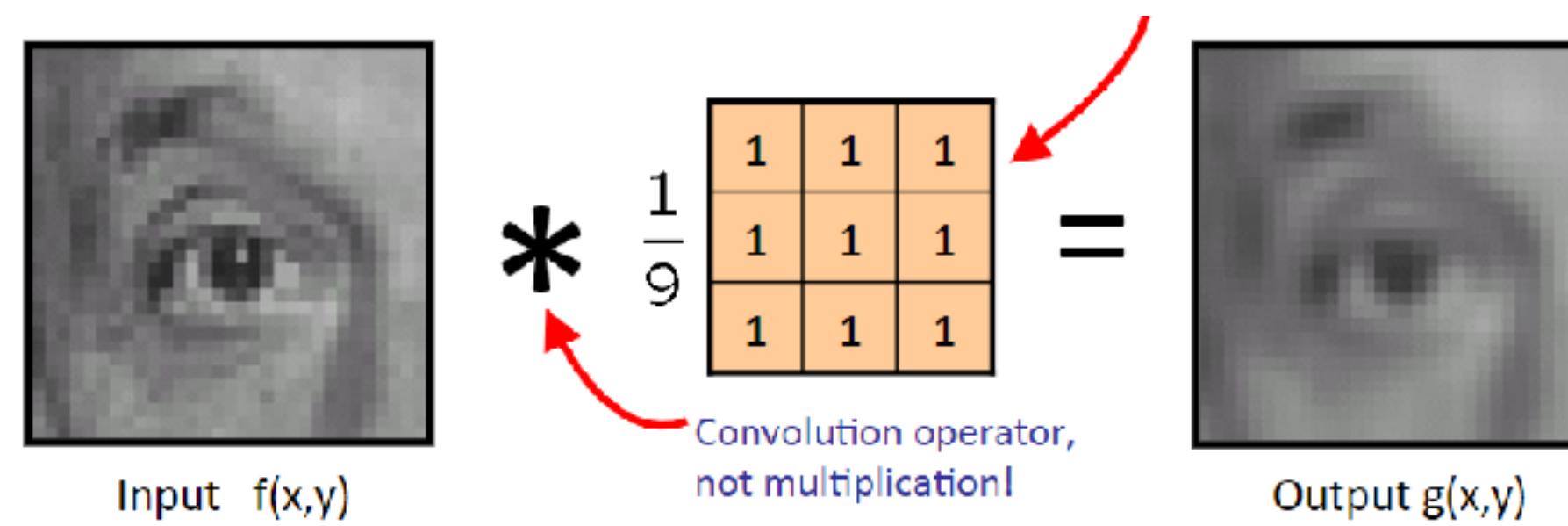
G_y

Filtering in Spatial Domain

Convolution filters



Smoothing filters



Derivative filters

-1	0	+1
-2	0	2
-1	0	+1

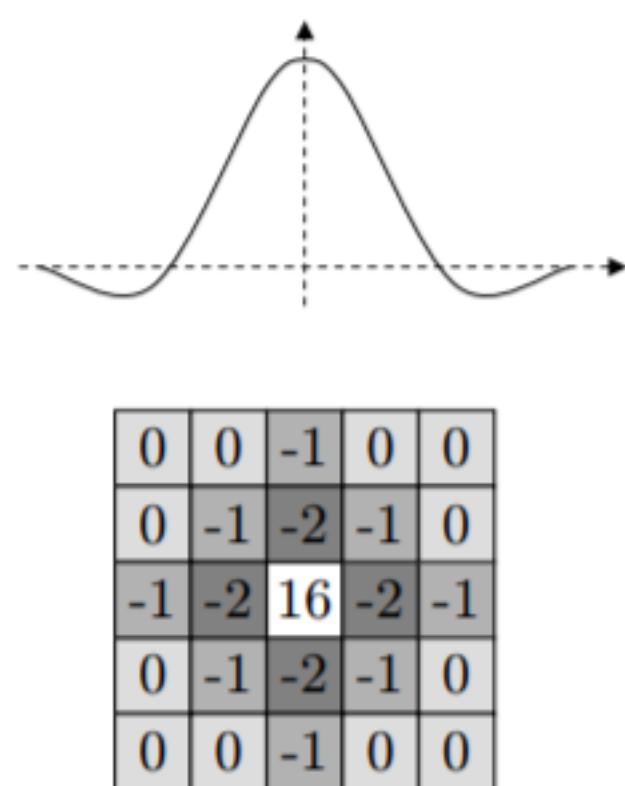
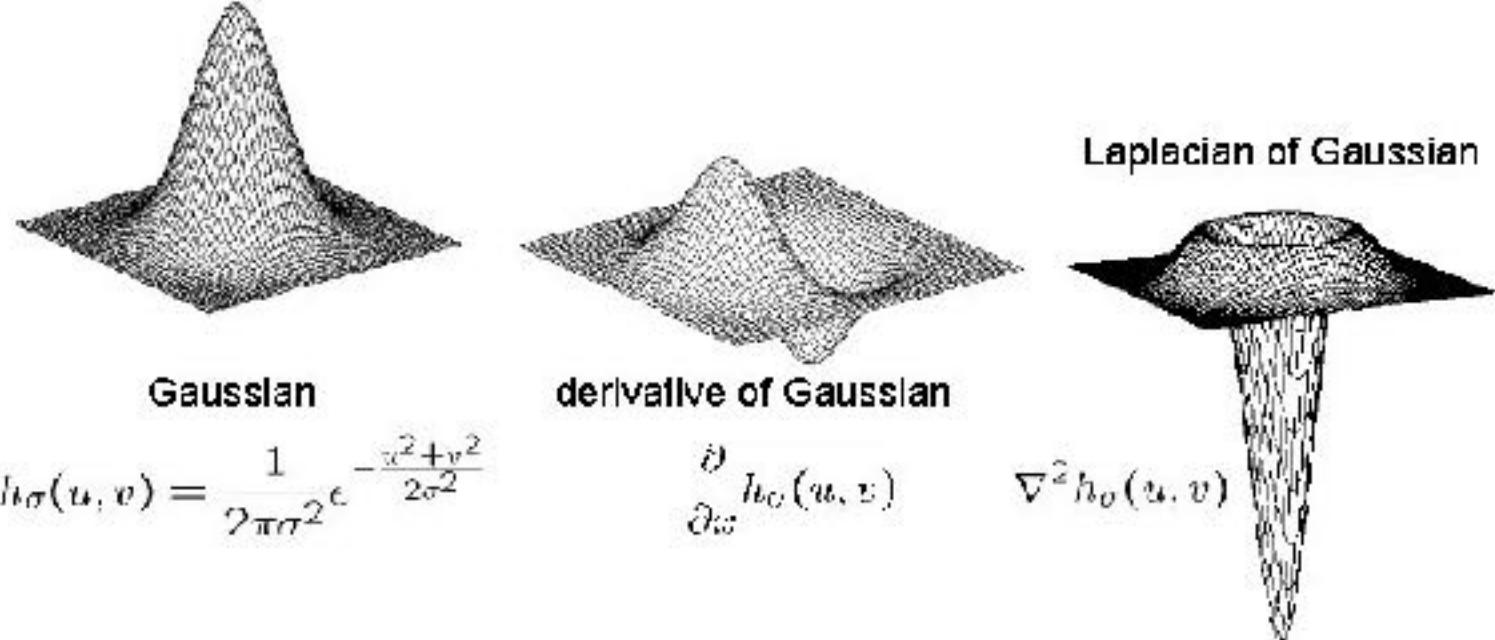
Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Laplacian of Gaussian

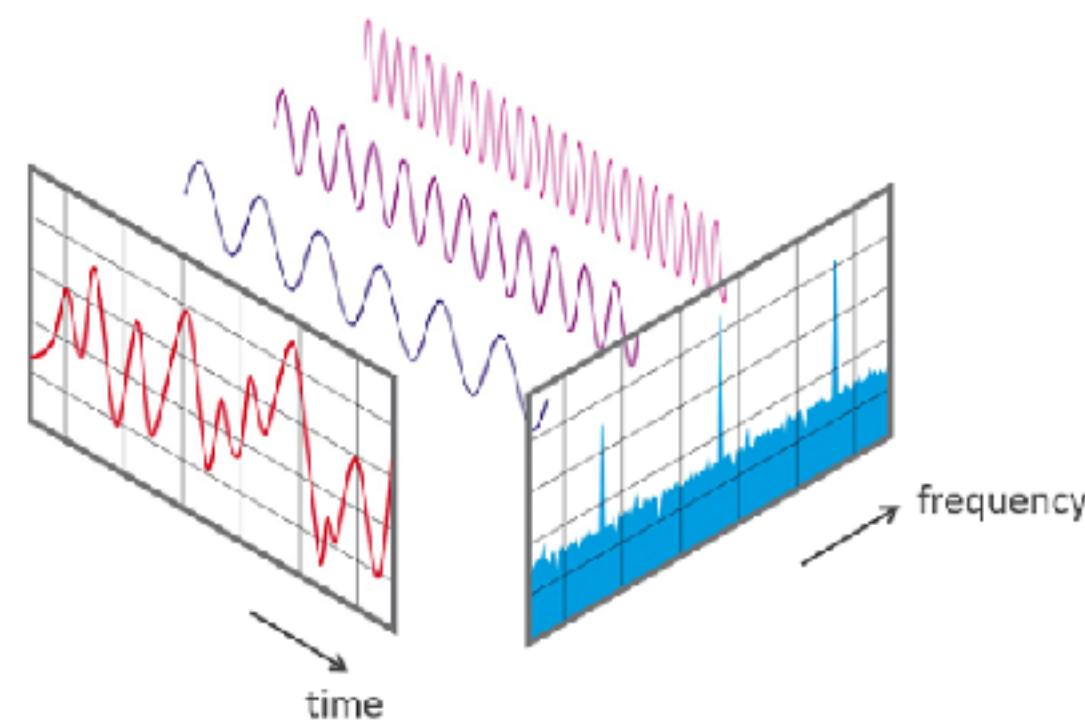
2D edge detection filters



Filtering in Spectral Domain

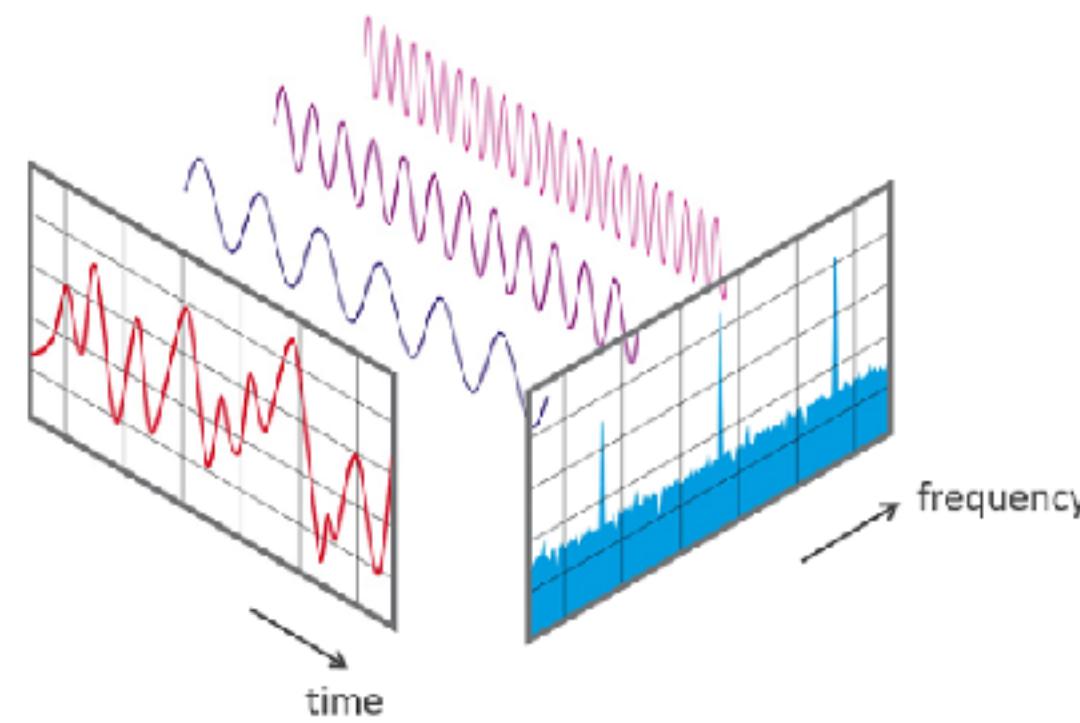
Filtering in Spectral Domain

Fourier transform

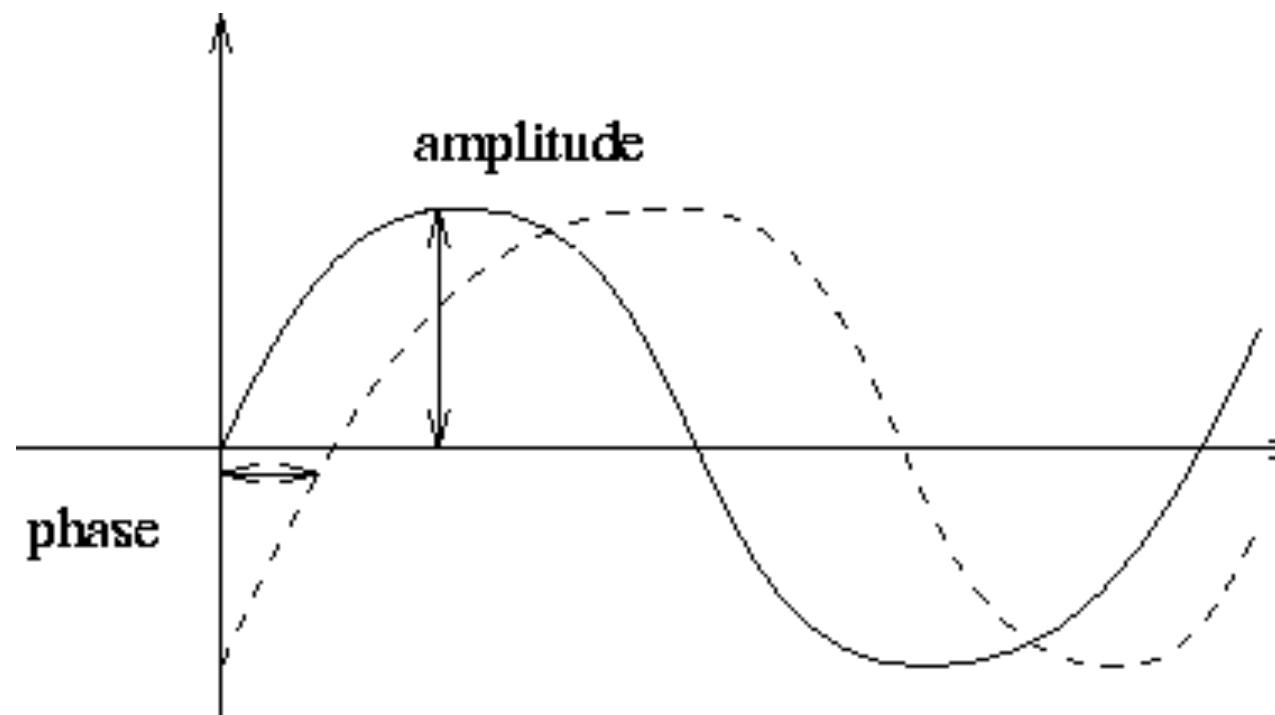


Filtering in Spectral Domain

Fourier transform

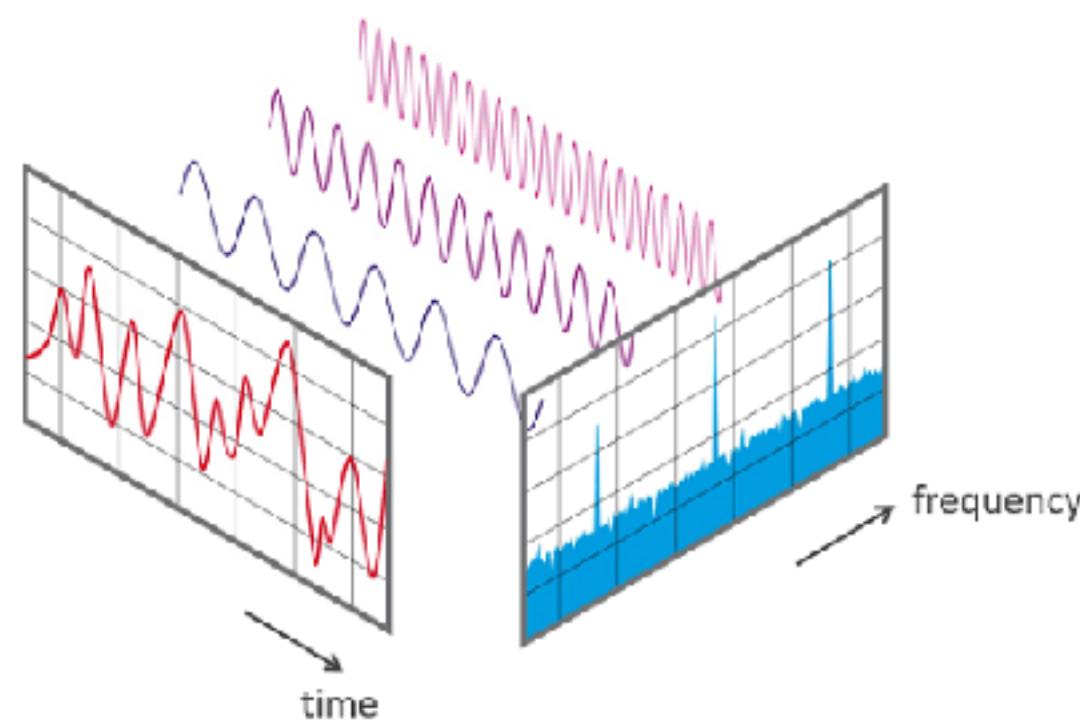


Magnitude and Phase

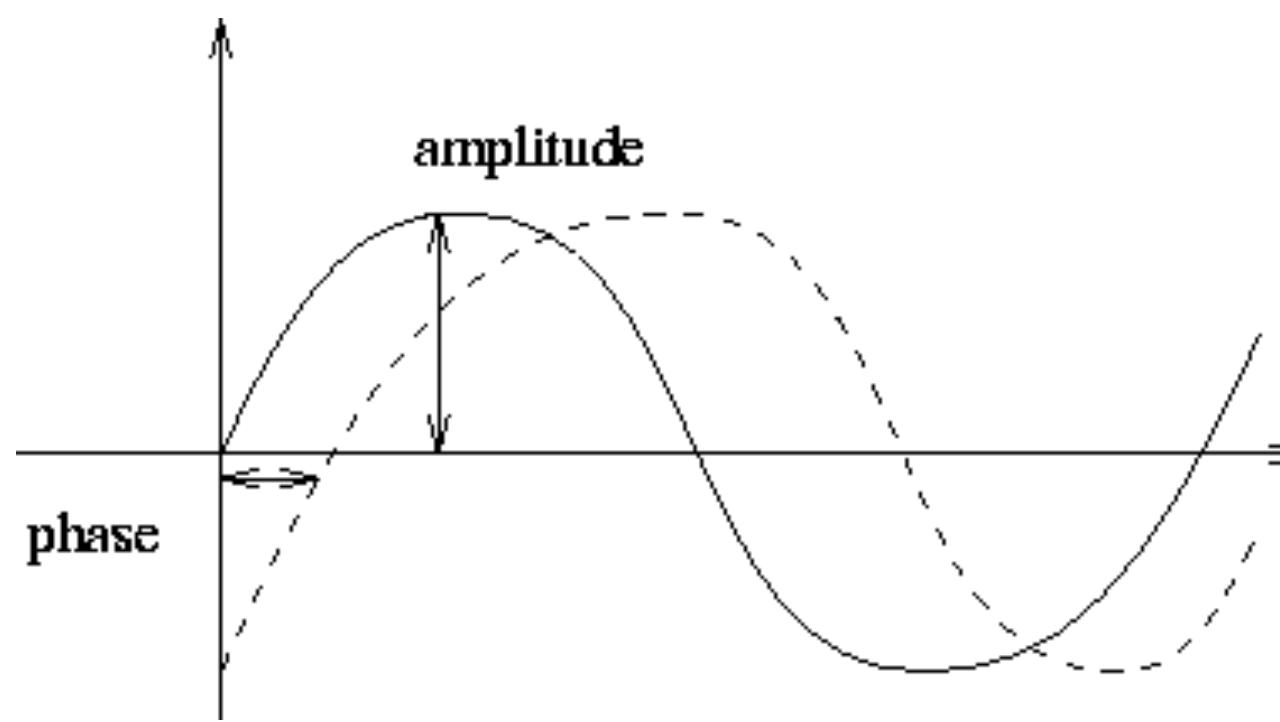


Filtering in Spectral Domain

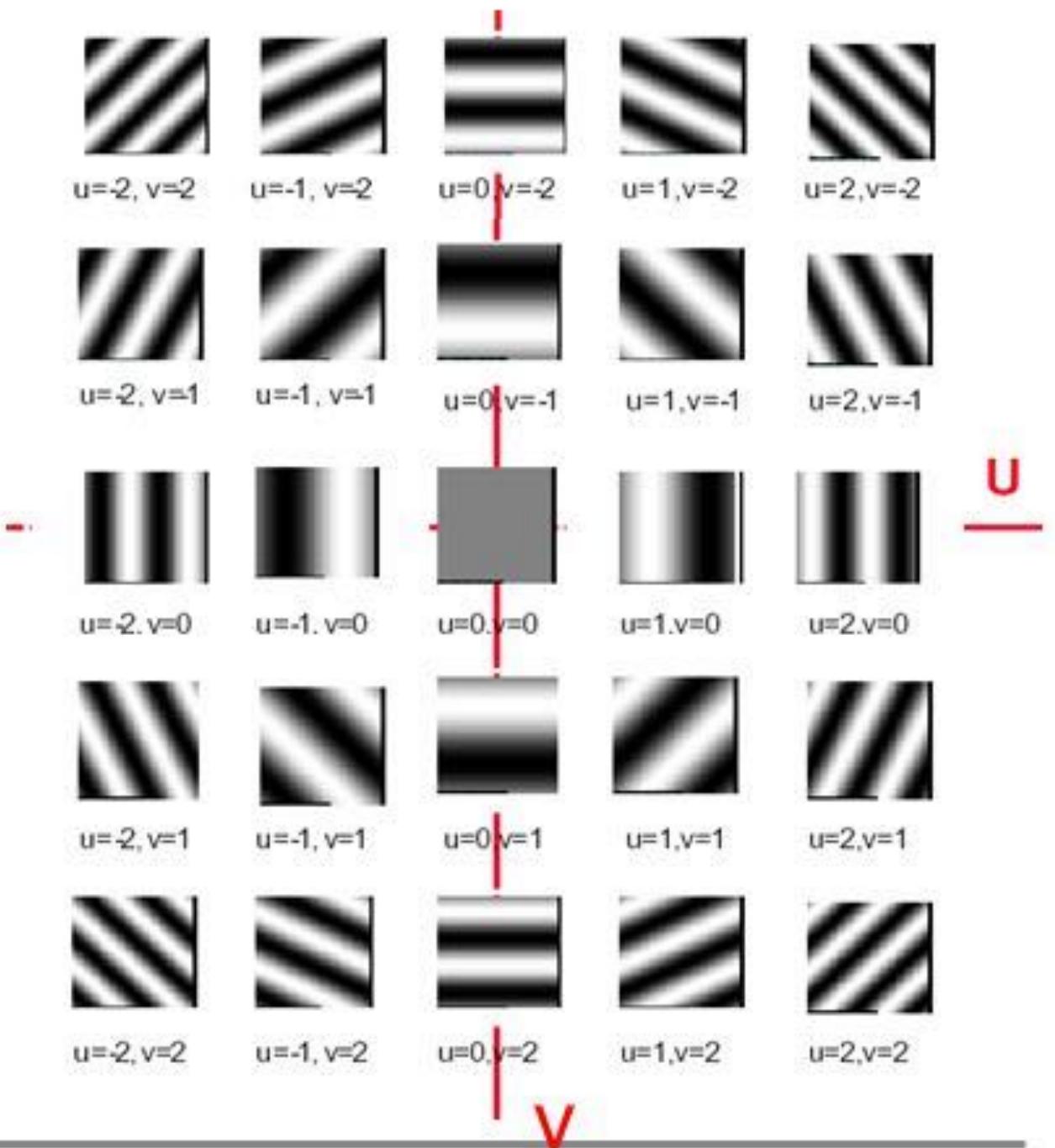
Fourier transform



Magnitude and Phase



Fourier basis functions



Filtering in Spectral Domain

Fourier transform

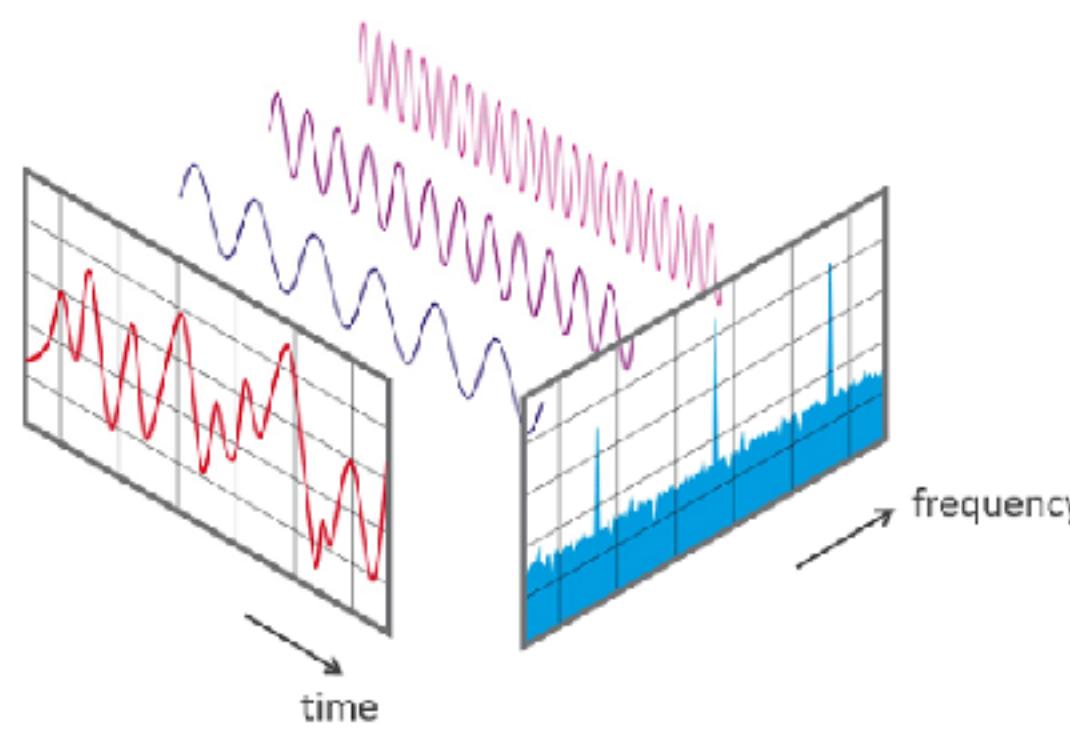
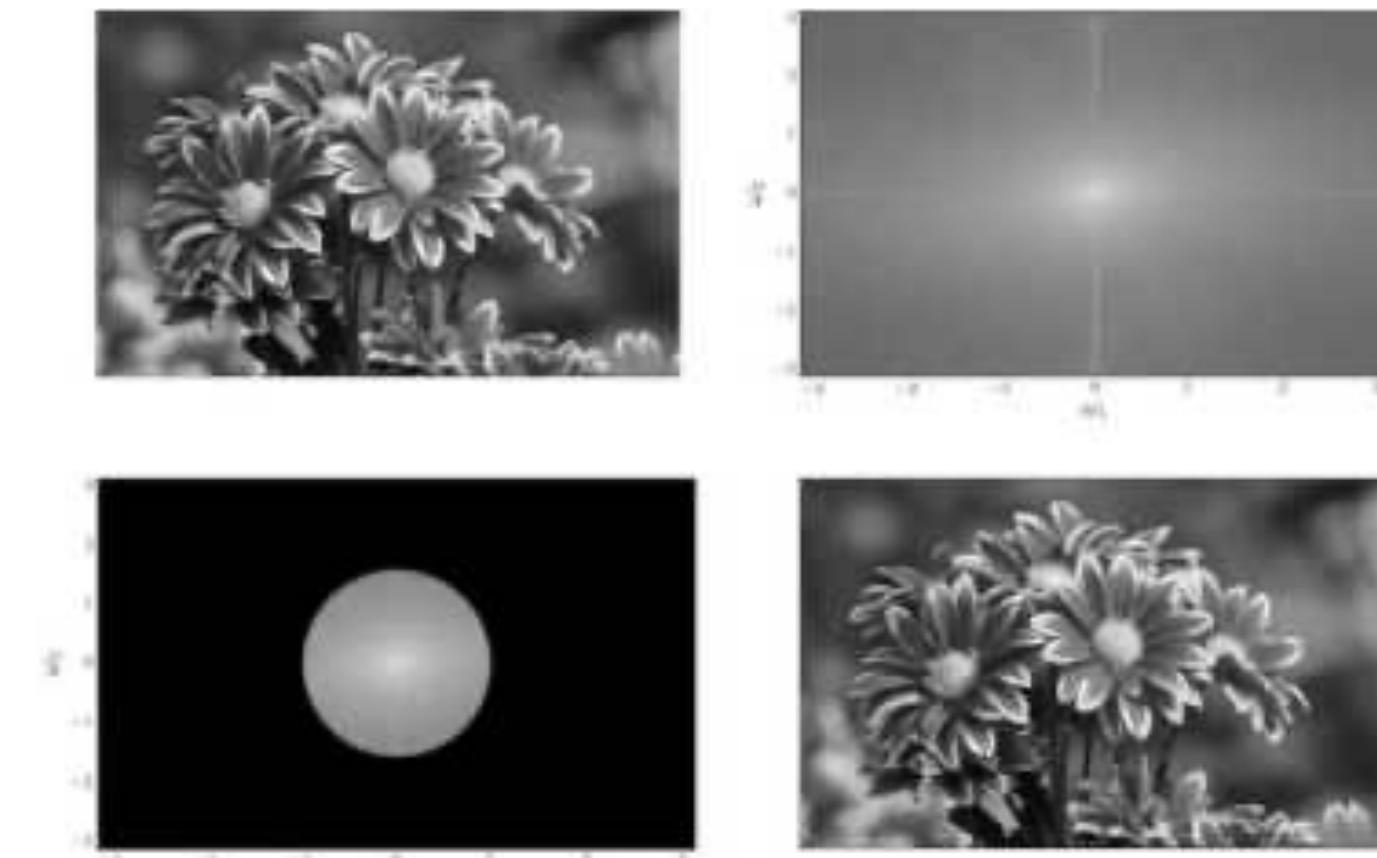
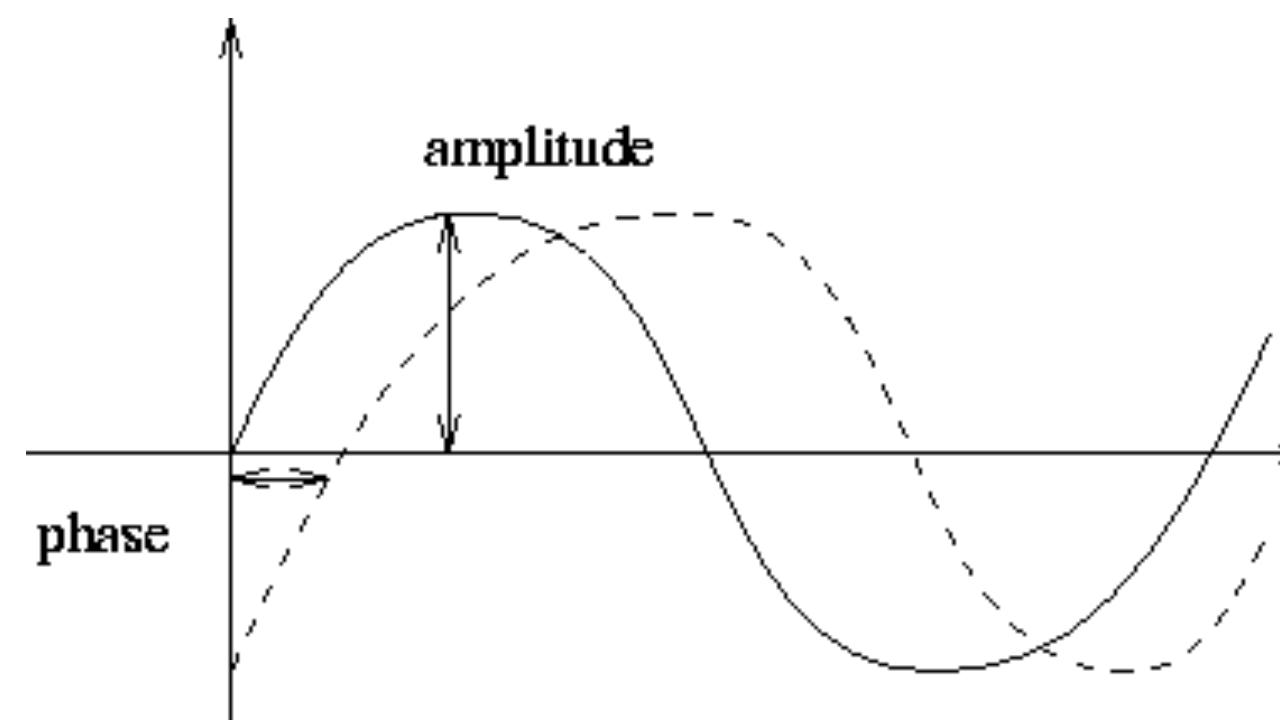


Image Spectra

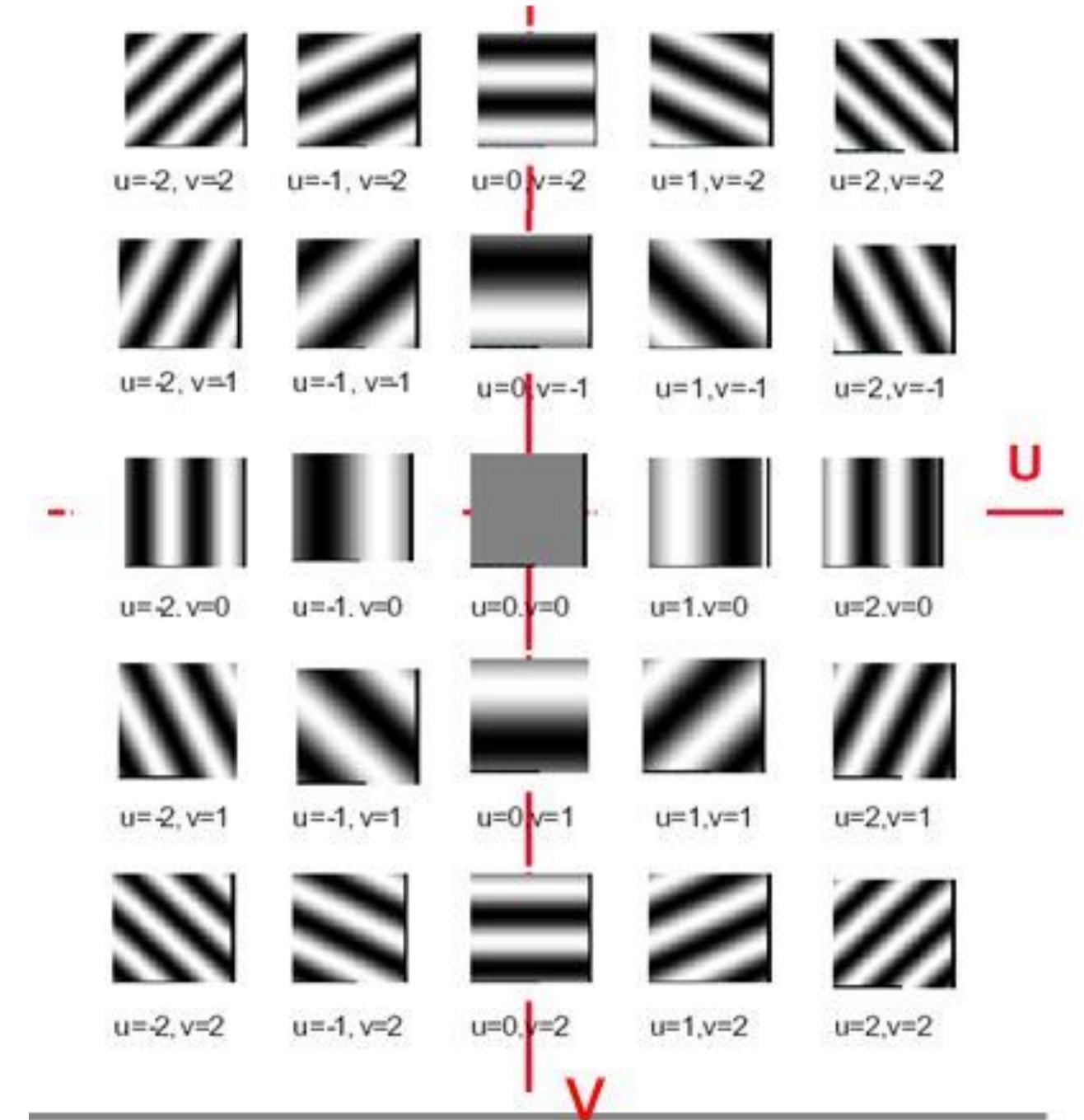


Magnitude and Phase



Convolution Theorem

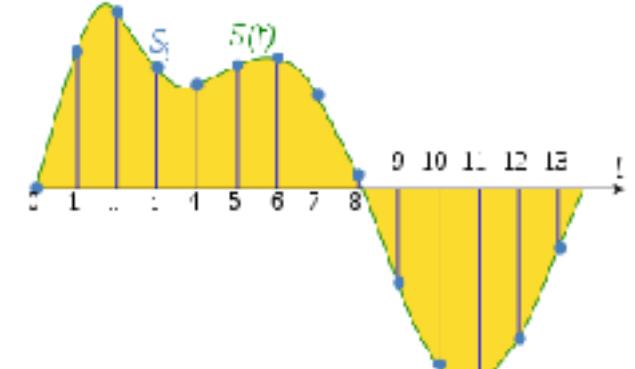
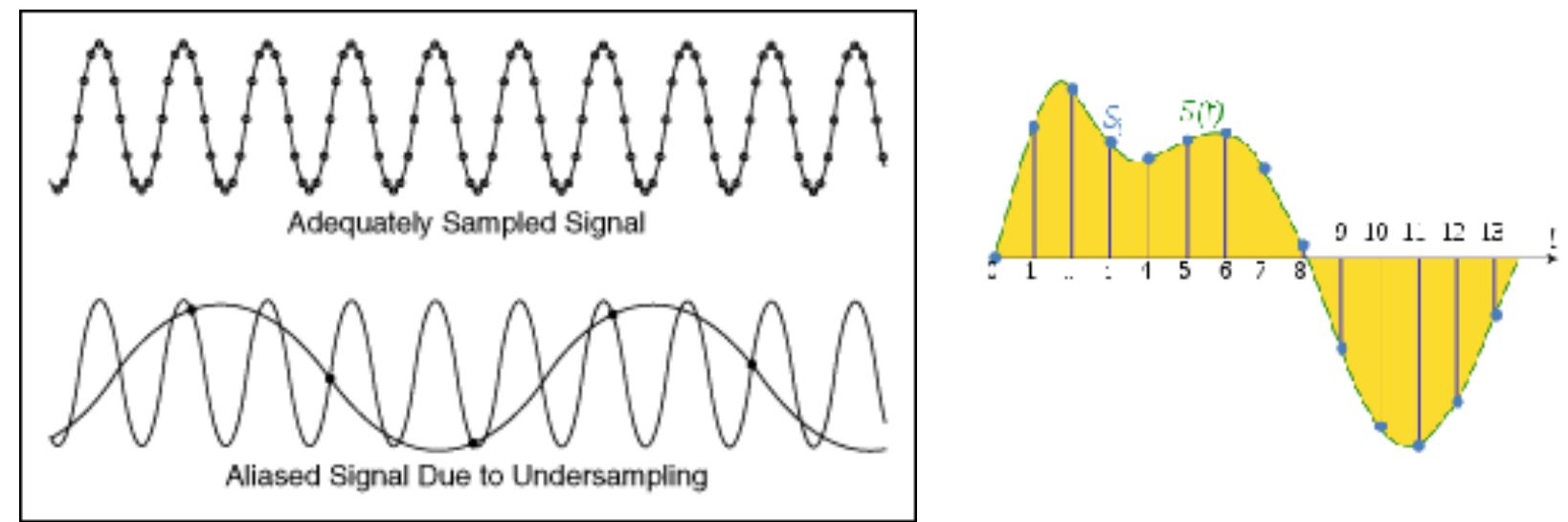
Fourier basis functions



Sampling/Blending/Image Period

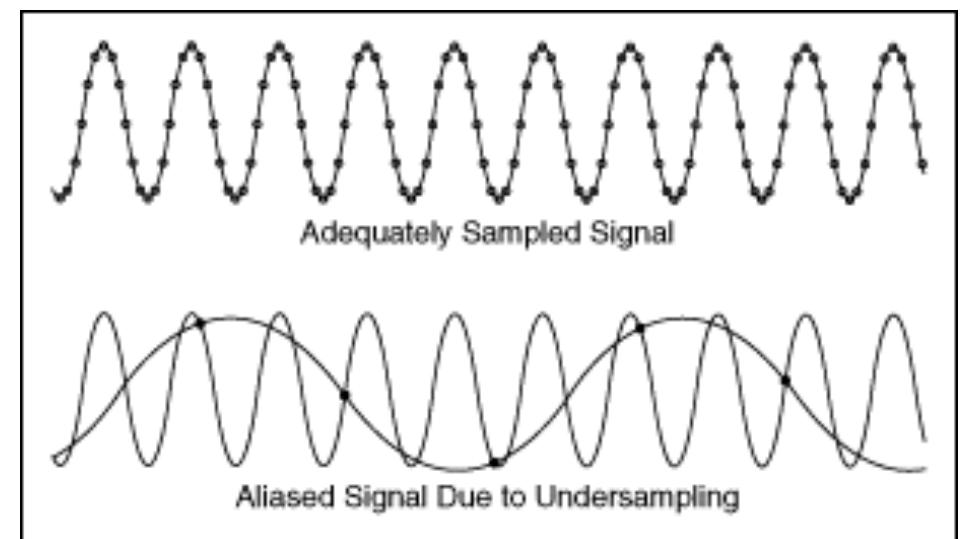
Sampling/Blending/Image Period

Sampling and aliasing



Sampling/Blending/Image Period

Sampling and aliasing

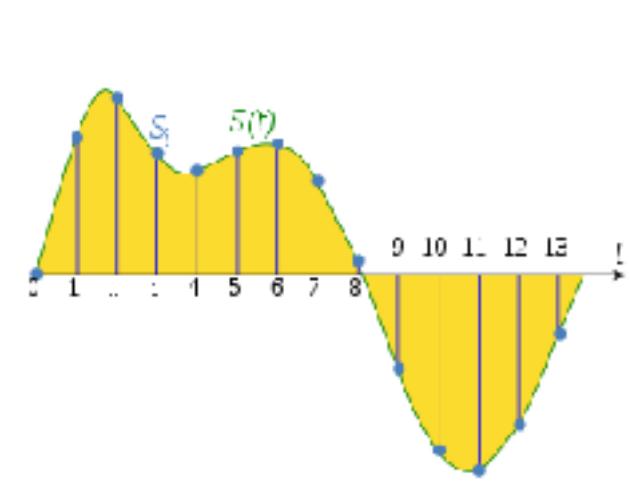
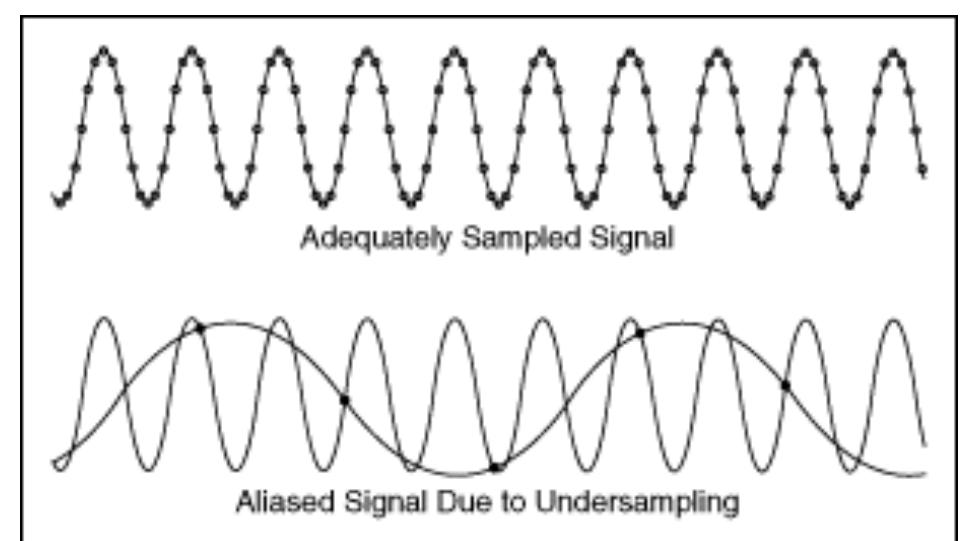


Aliasing



Sampling/Blending/Image Period

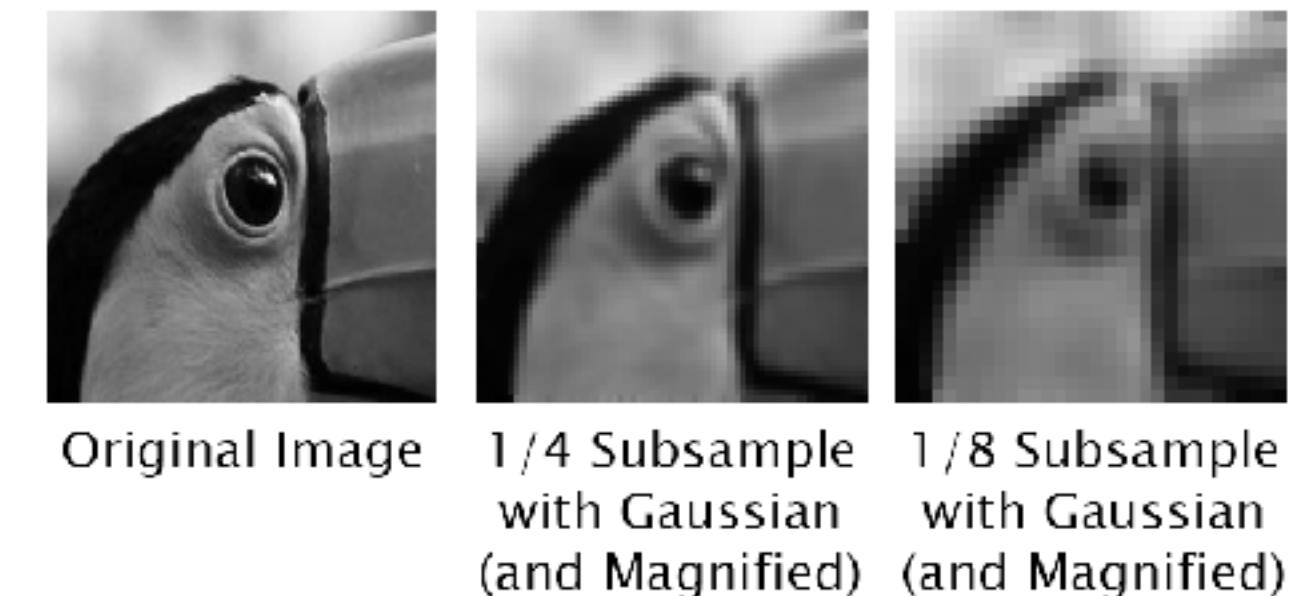
Sampling and aliasing



Aliasing

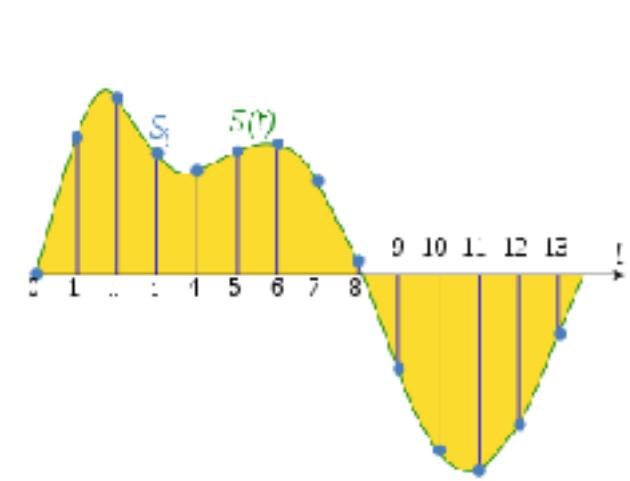
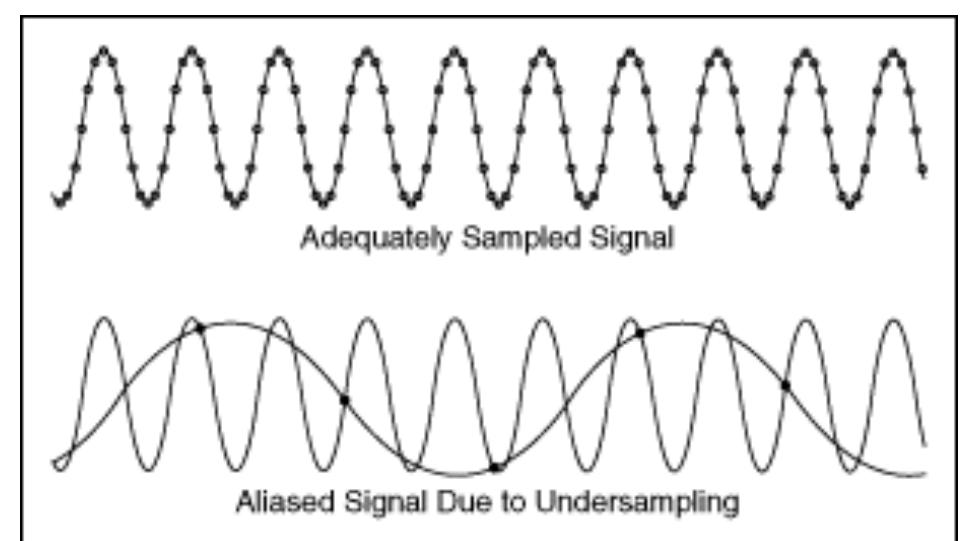


Preventing aliasing



Sampling/Blending/Image Period

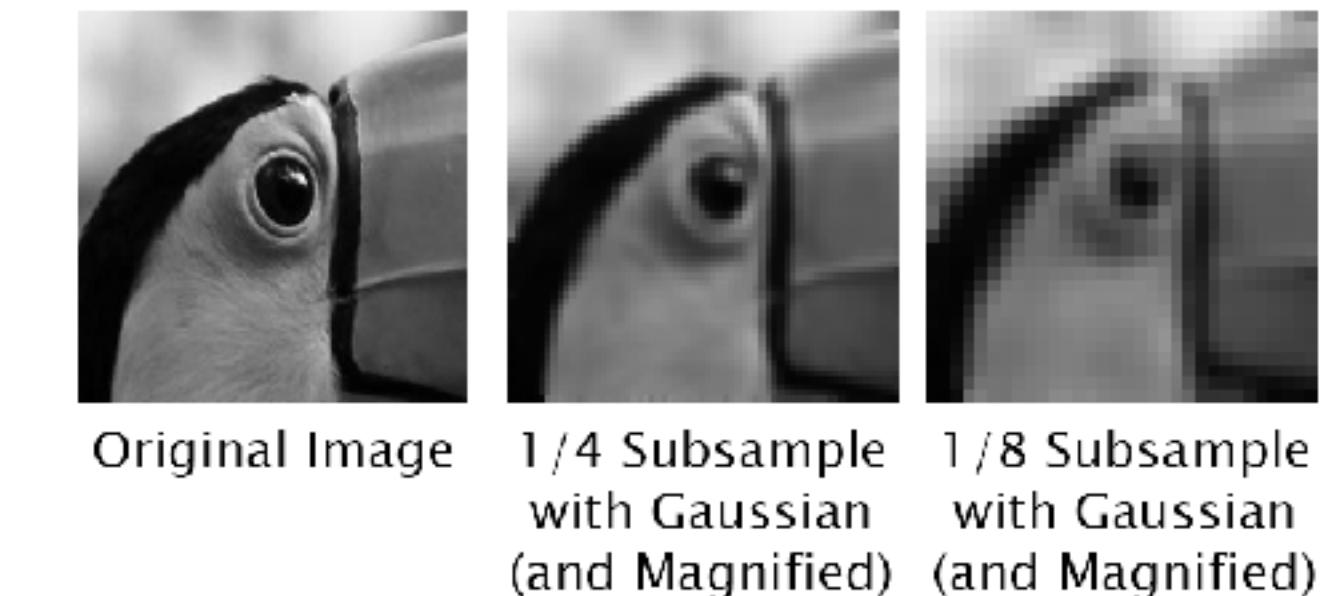
Sampling and aliasing



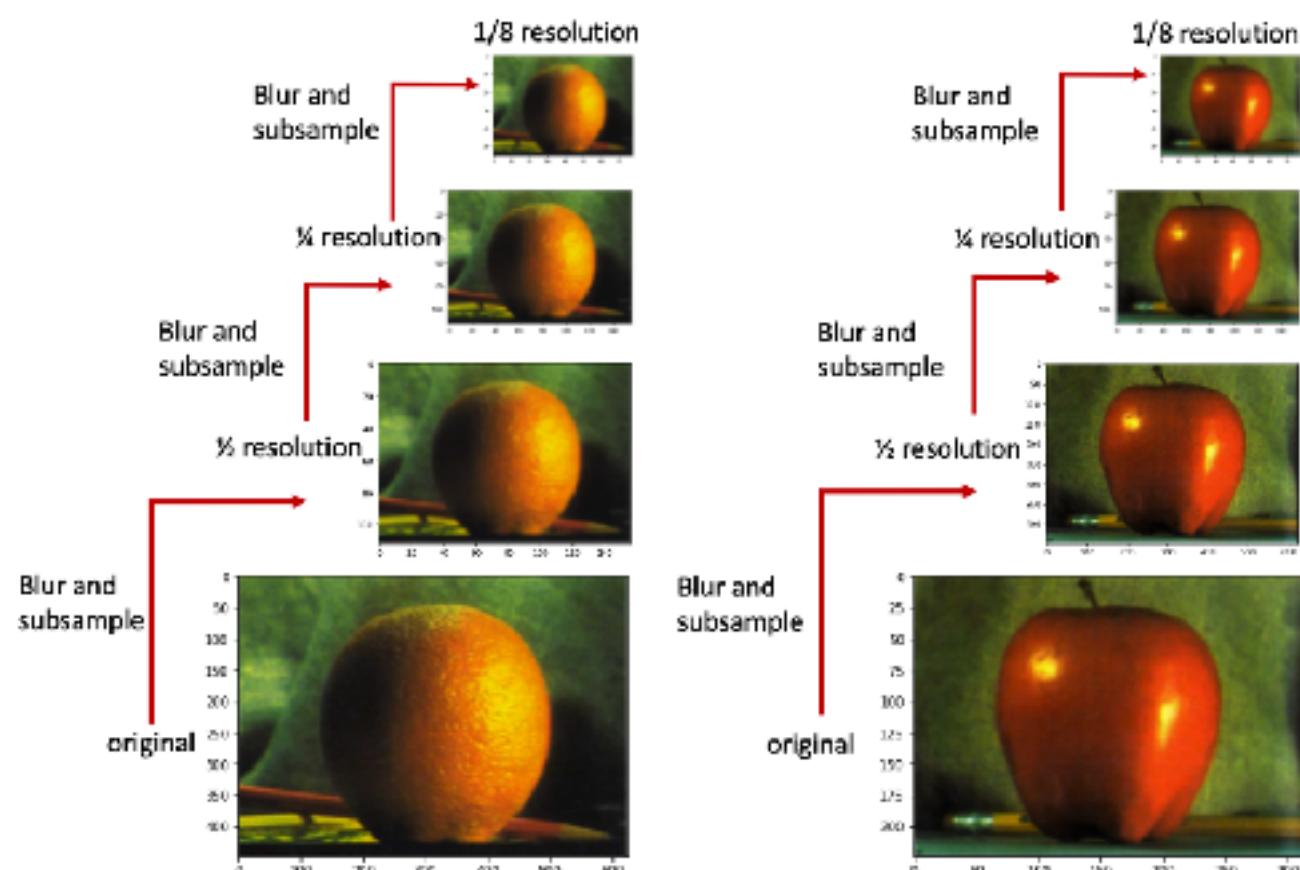
Aliasing



Preventing aliasing

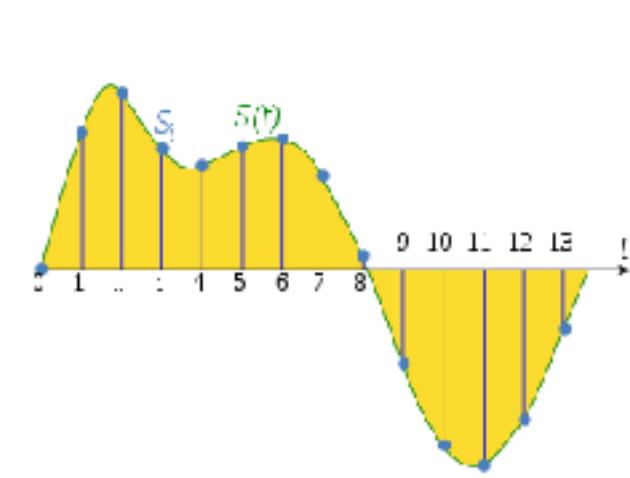
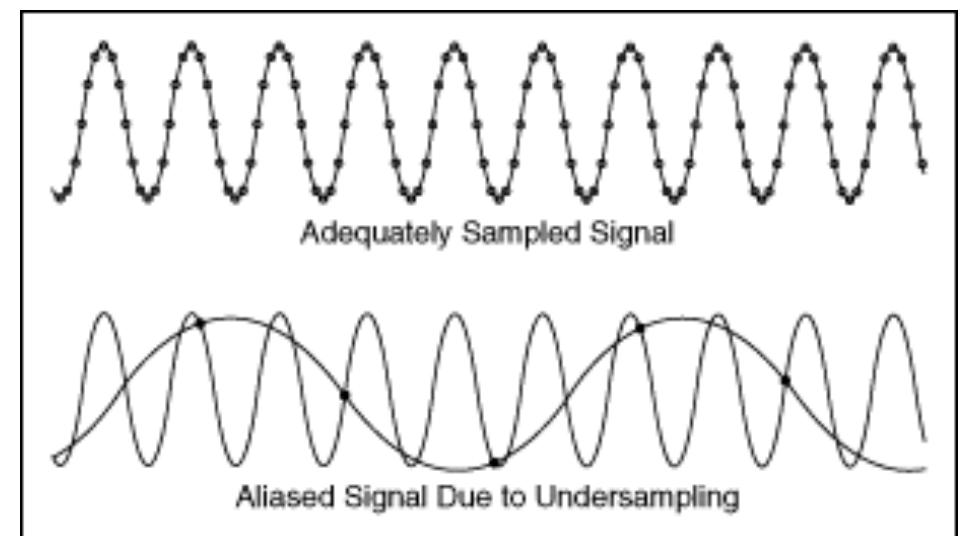


Gaussian pyramids



Sampling/Blending/Image Period

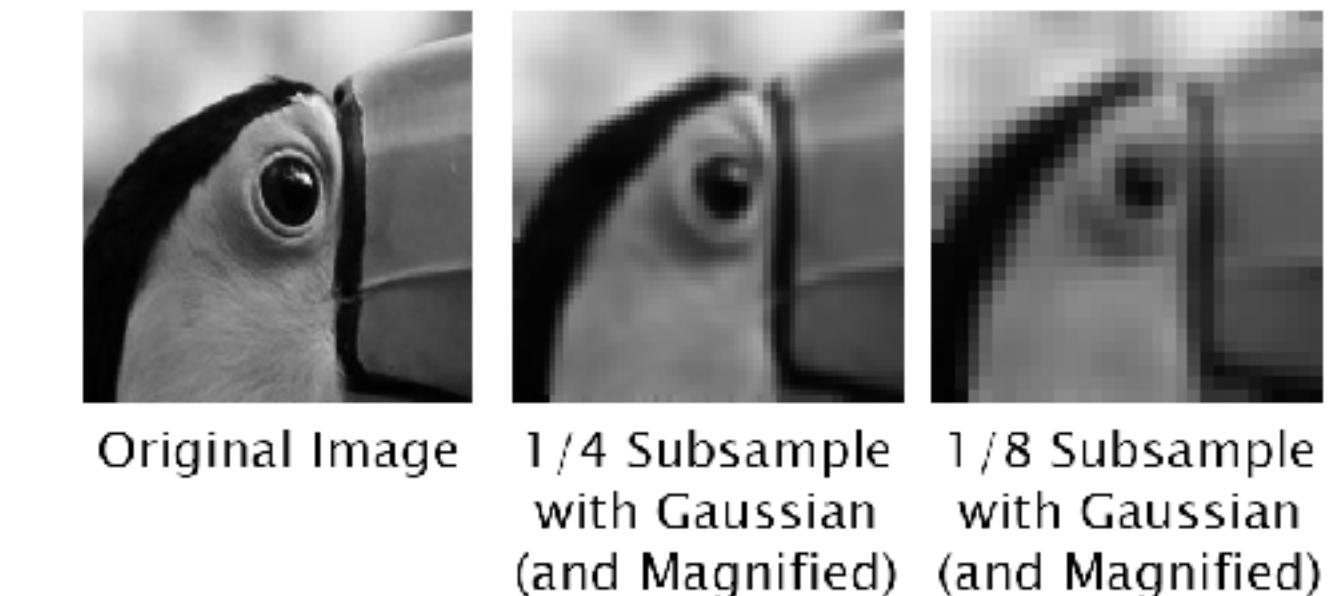
Sampling and aliasing



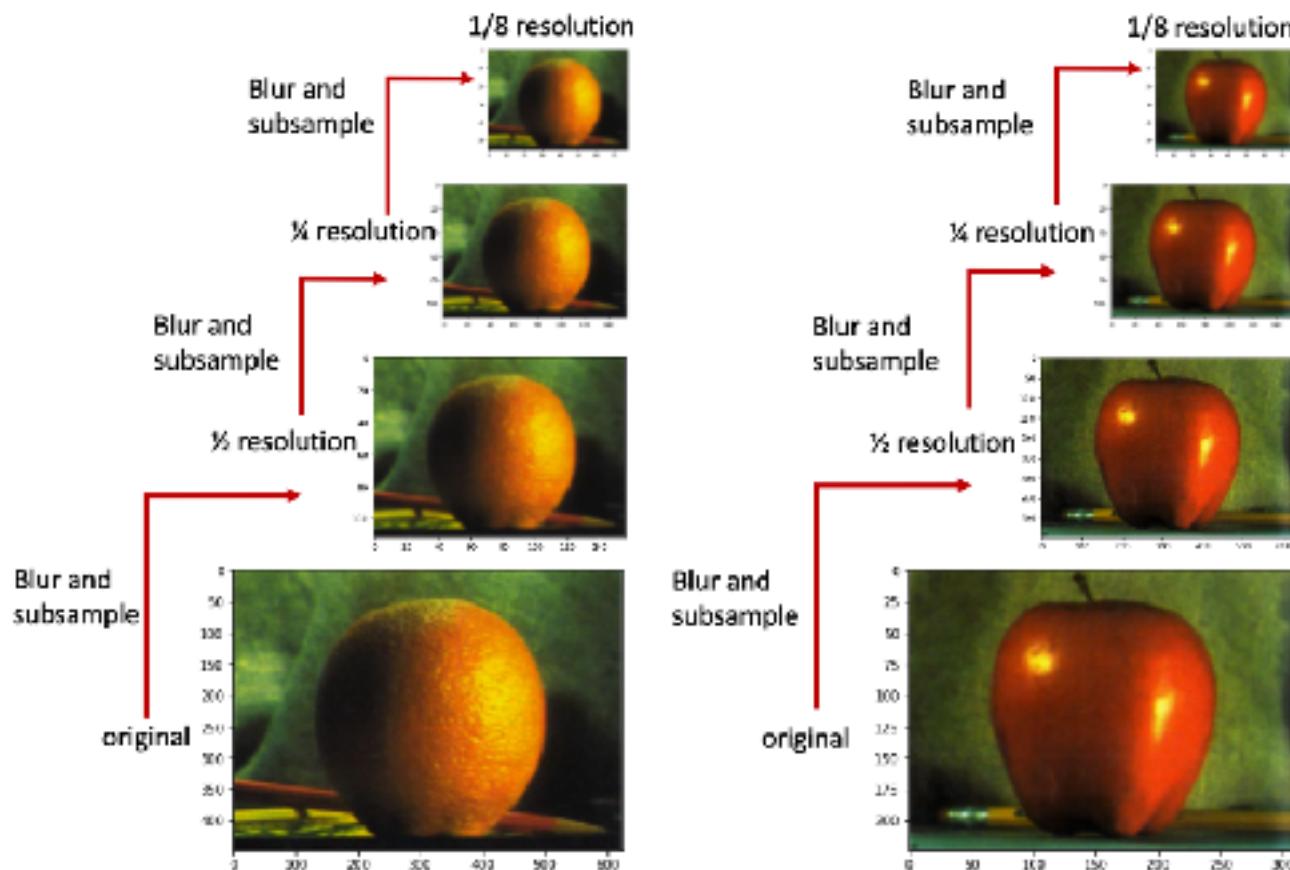
Aliasing



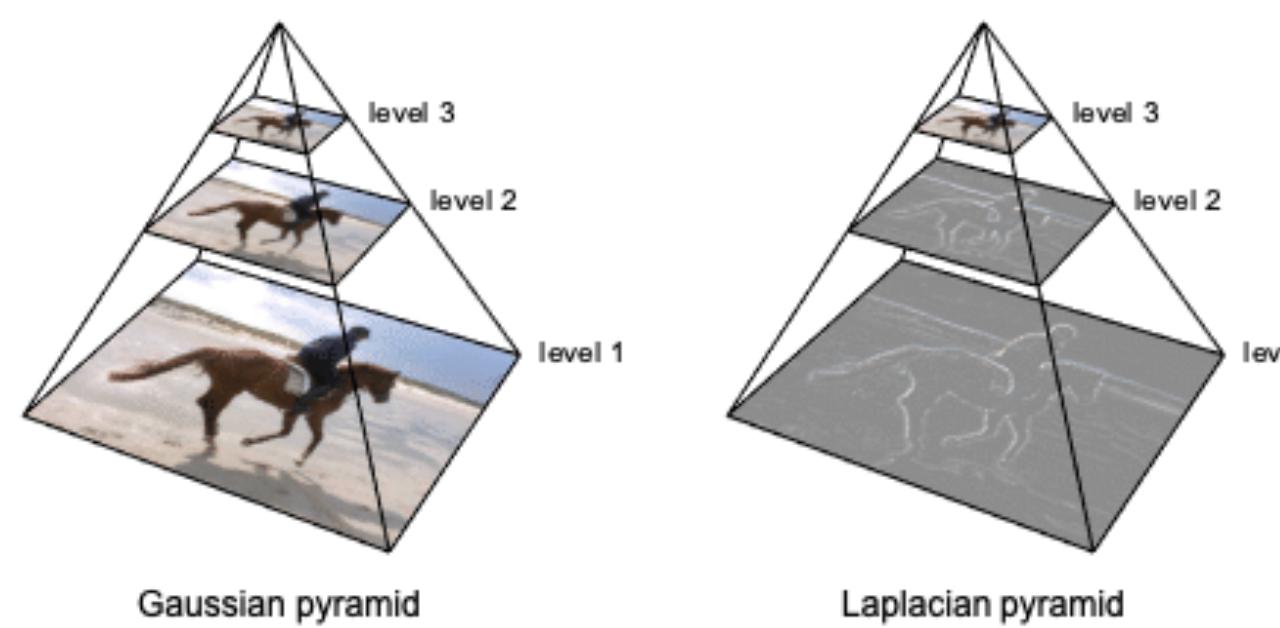
Preventing aliasing



Gaussian pyramids

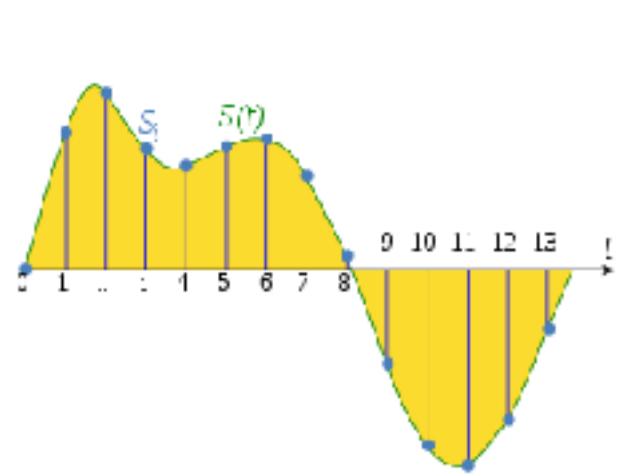
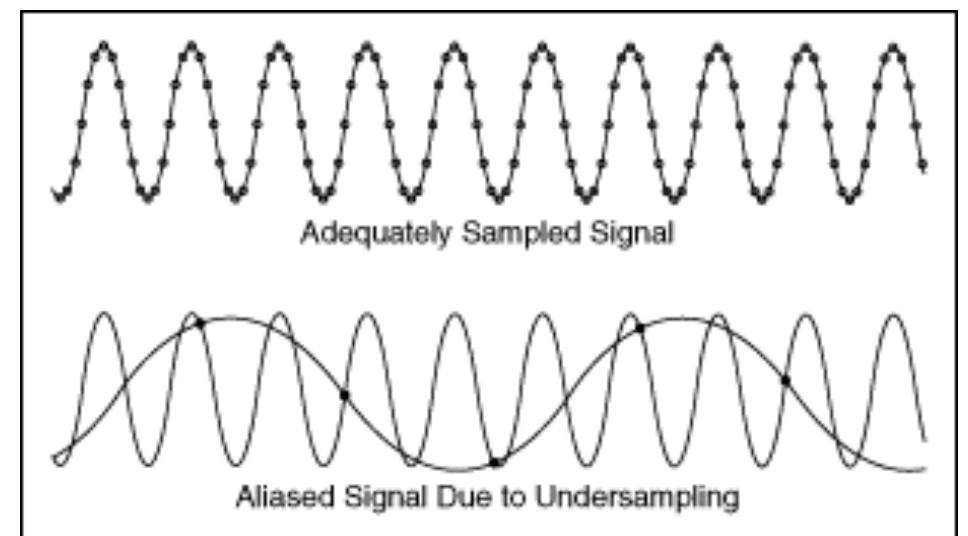


Laplacian pyramids



Sampling/Blending/Image Period

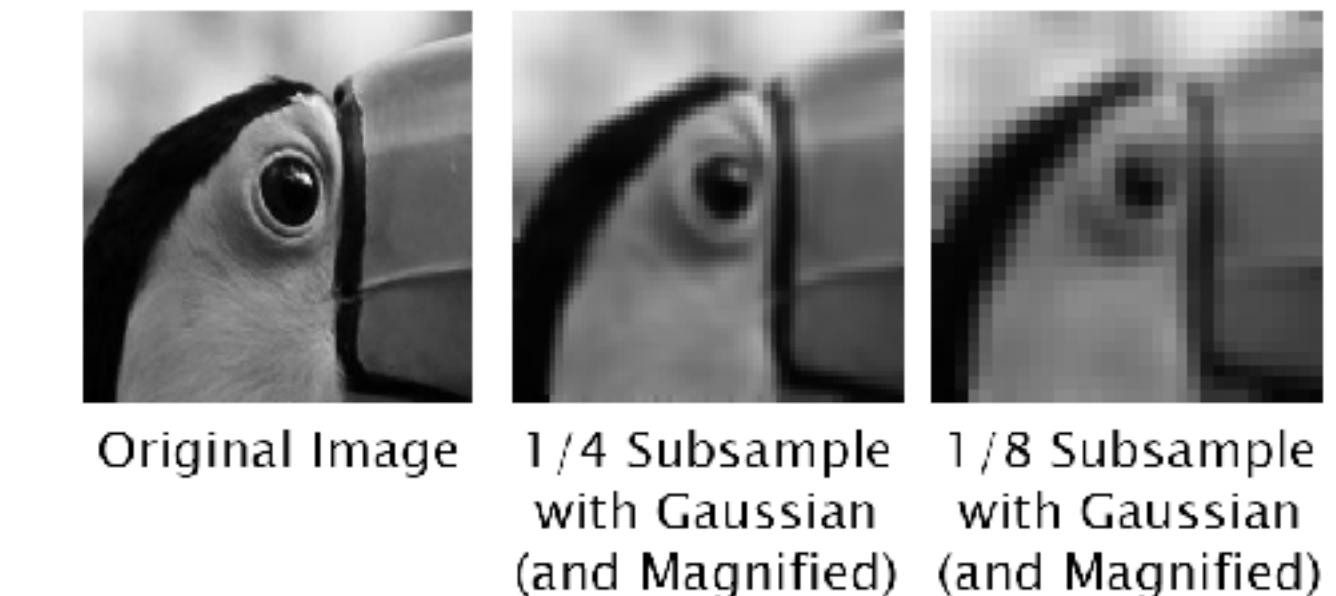
Sampling and aliasing



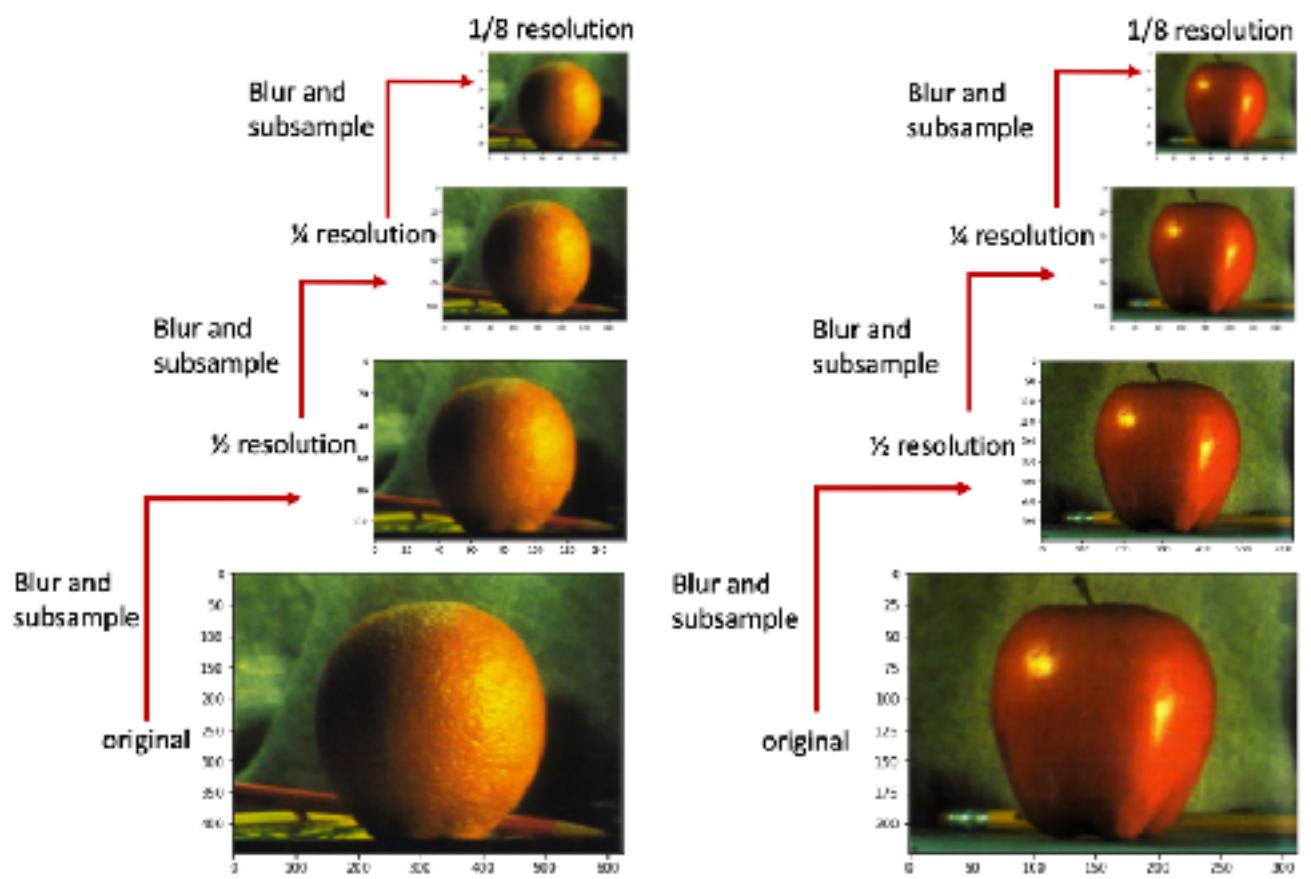
Aliasing



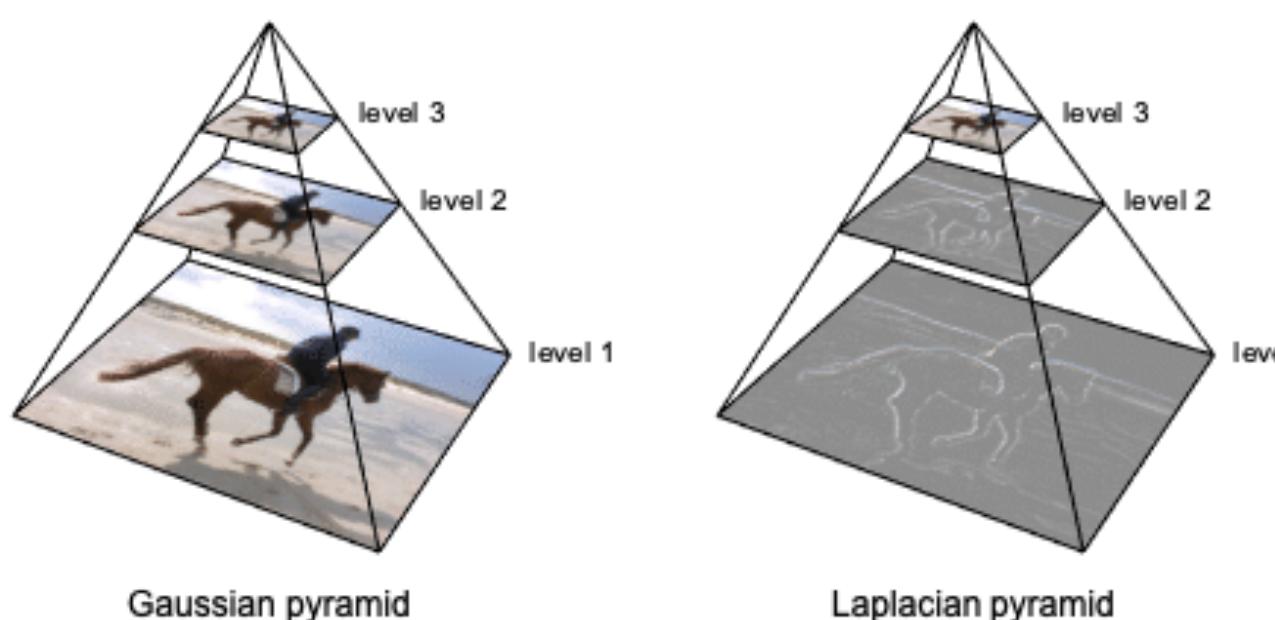
Preventing aliasing



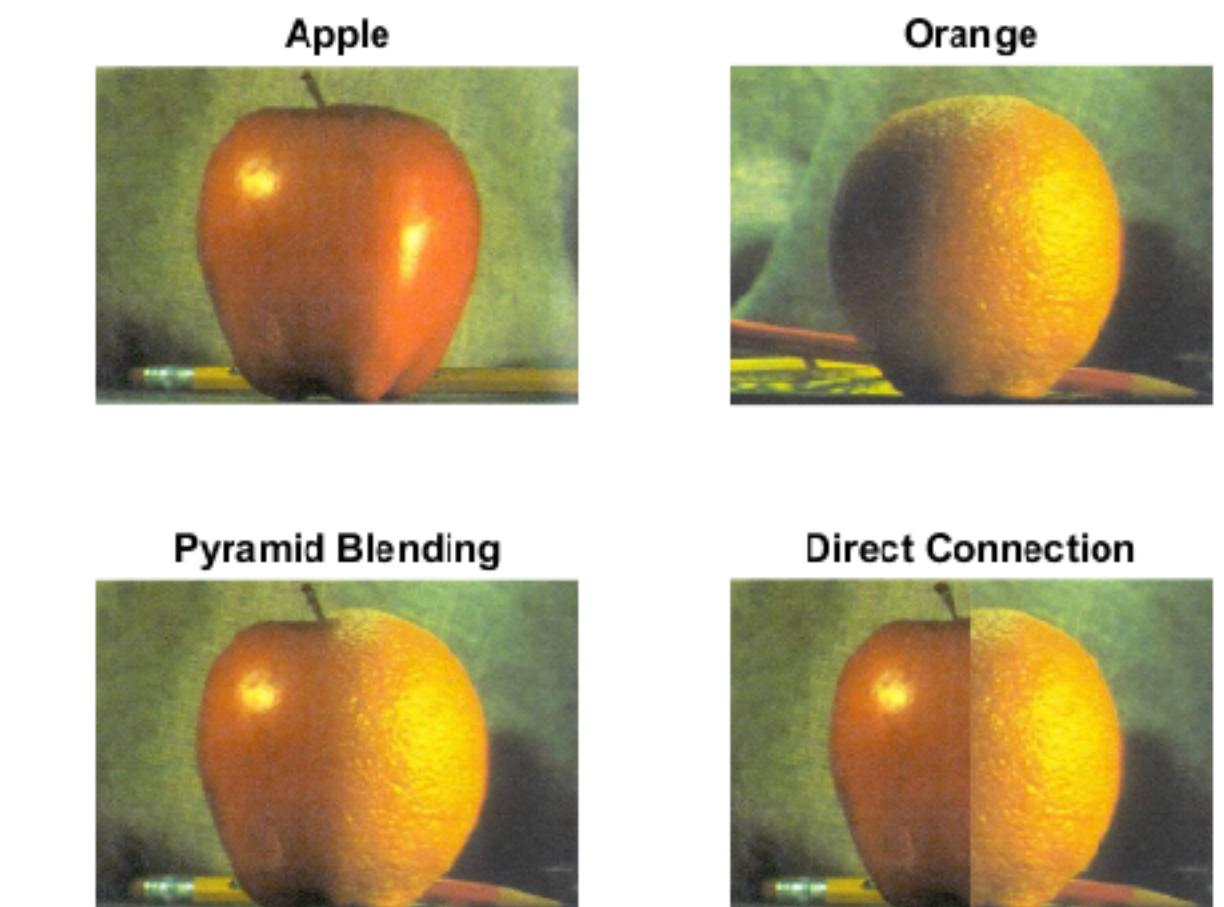
Gaussian pyramids



Laplacian pyramids



Blending



Edge Detectors

Edge Detectors

Image gradients

Definition: Image Gradient (Mathematically)

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, \frac{\delta F}{\delta y} \end{bmatrix}$$

measure of change in
image function (F) in
 x and y


$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, 0 \end{bmatrix}$$


$$\nabla F = \begin{bmatrix} 0, \frac{\delta F}{\delta y} \end{bmatrix}$$


$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, \frac{\delta F}{\delta y} \end{bmatrix}$$



(Image adapted from Khan Academy)

Edge Detectors

Image gradients

Definition: Image Gradient (Mathematically)

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, \frac{\delta F}{\delta y} \end{bmatrix}$$

measure of change in
image function (F) in
 x and y

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, \frac{\delta F}{\delta y} \end{bmatrix}$$

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, 0 \end{bmatrix}$$

$$\nabla F = \begin{bmatrix} 0, \frac{\delta F}{\delta y} \end{bmatrix}$$



Edge maps



Edge Detectors

Image gradients

Definition: Image Gradient (Mathematically)

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, \frac{\delta F}{\delta y} \end{bmatrix}$$

measure of change in image function (F), in x and y

$$\nabla F = \begin{bmatrix} \frac{\delta F}{\delta x}, 0 \end{bmatrix}$$
$$\nabla F = \begin{bmatrix} 0, \frac{\delta F}{\delta y} \end{bmatrix}$$

Code adapted from OpenCV

Edge maps



Canny edge detector

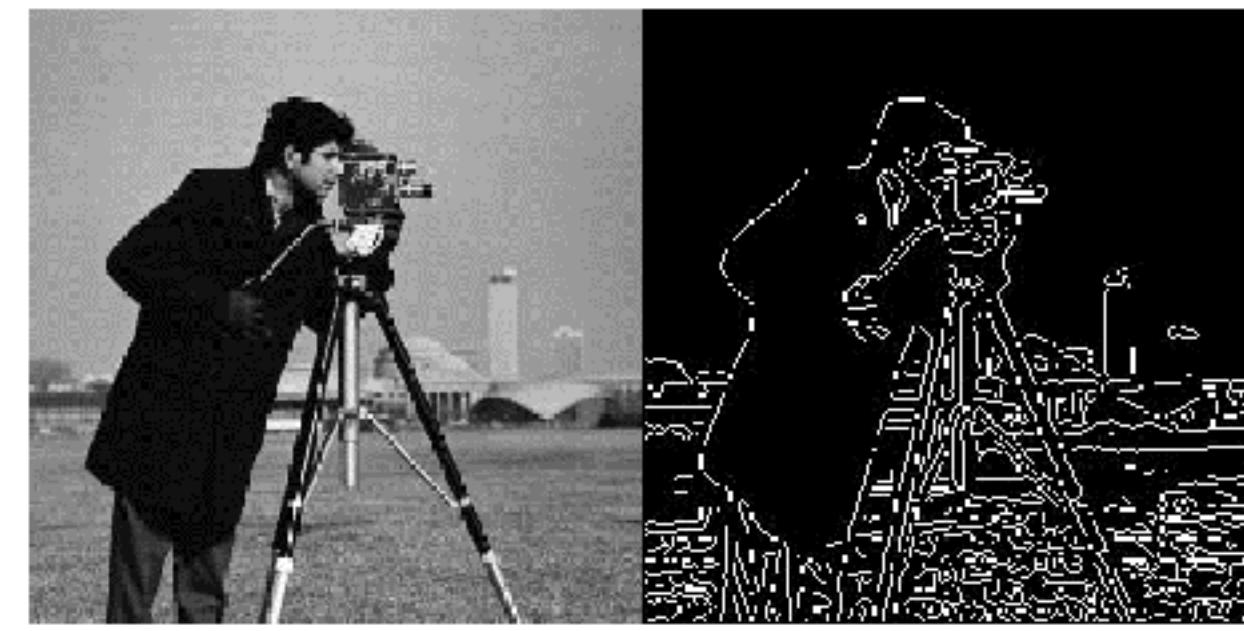
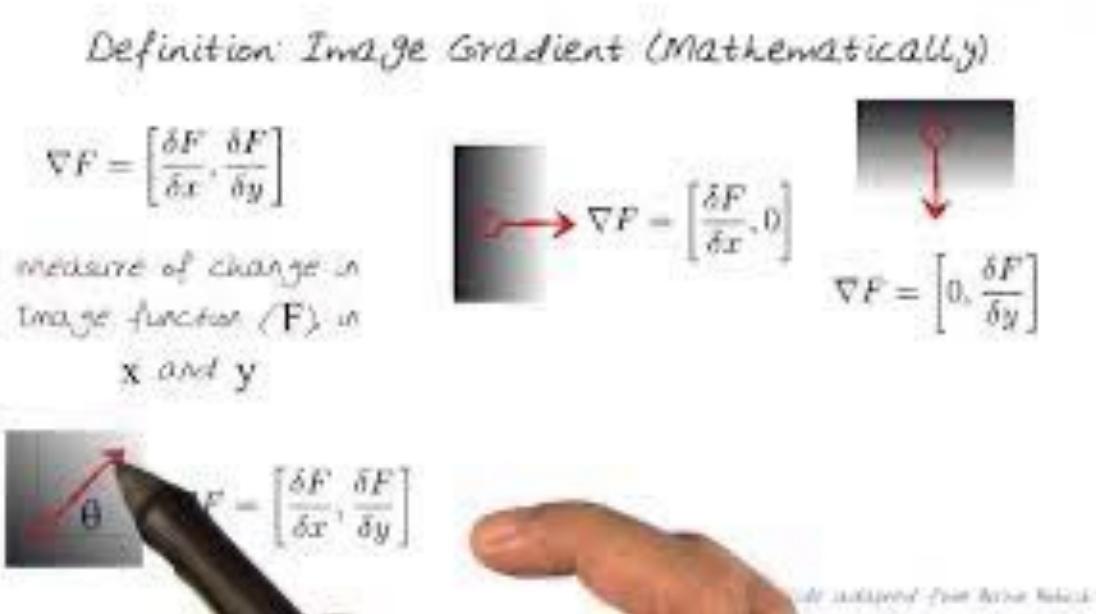


Figure 1: The cameraman image and its edges extracted

Edge Detectors

Image gradients



Edge maps



Canny edge detector

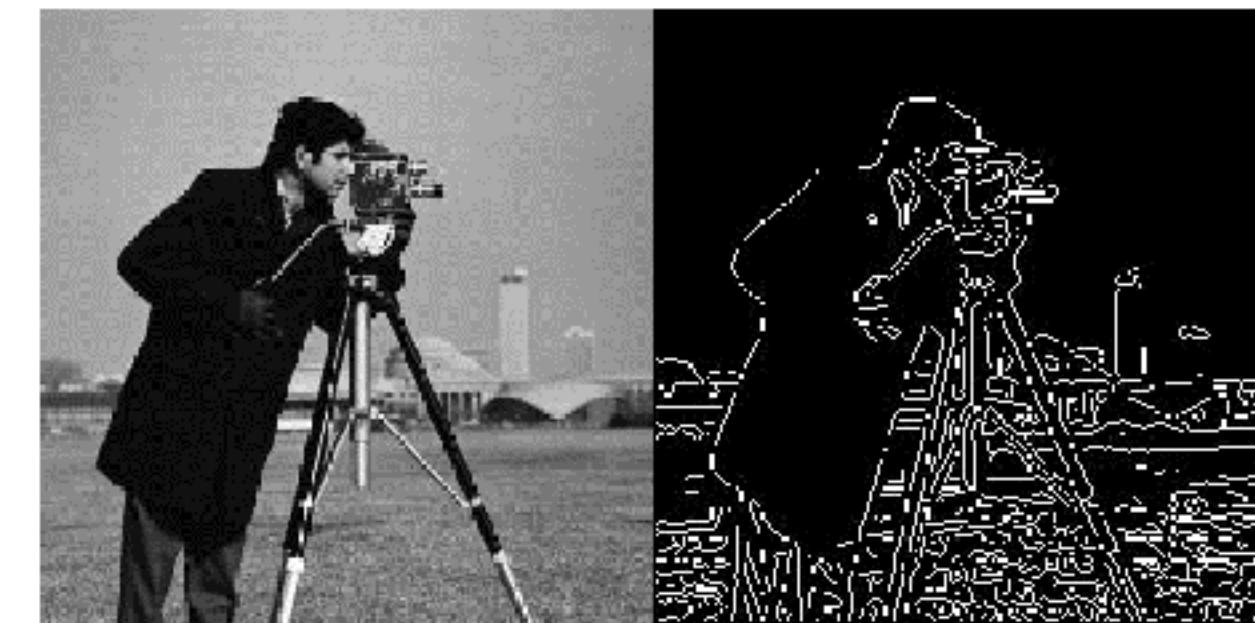
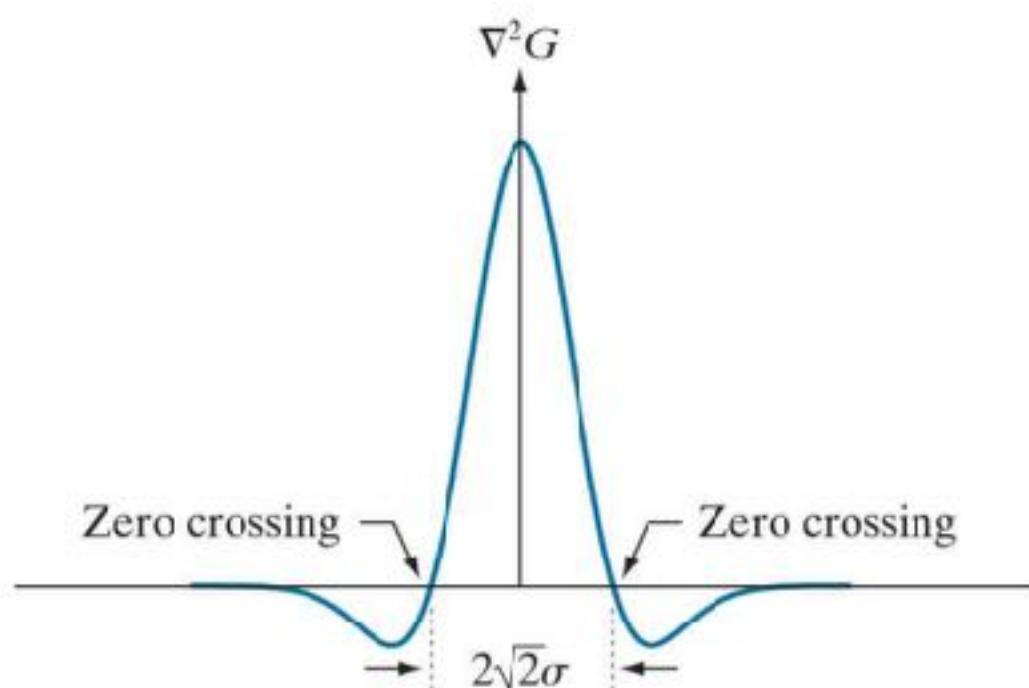


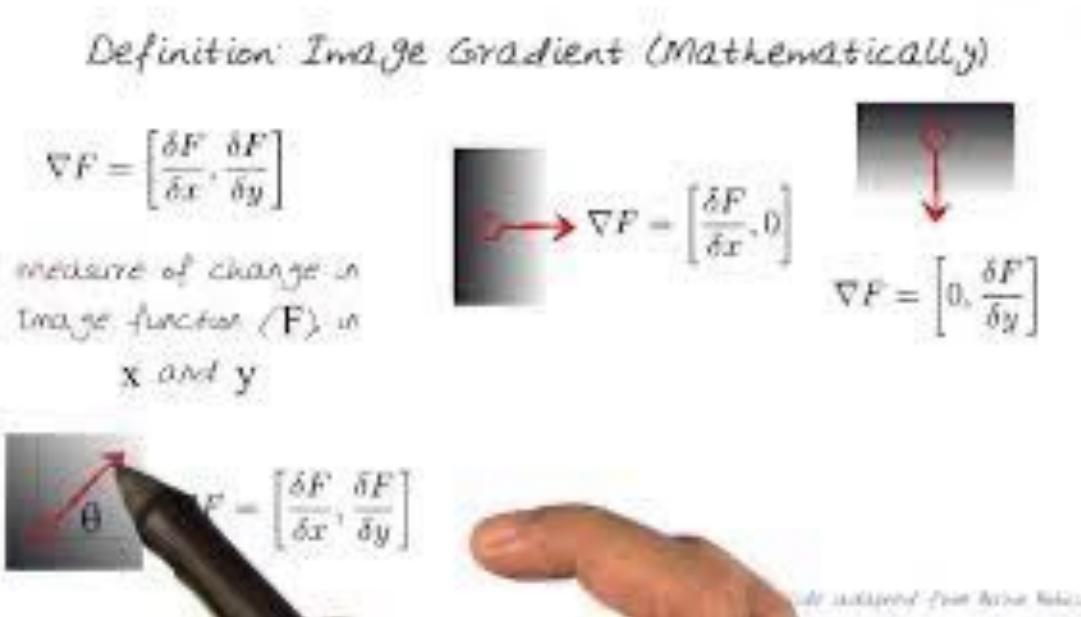
Figure 1: The cameraman image and its edges extracted

Laplacian/ DOG



Edge Detectors

Image gradients



Edge maps

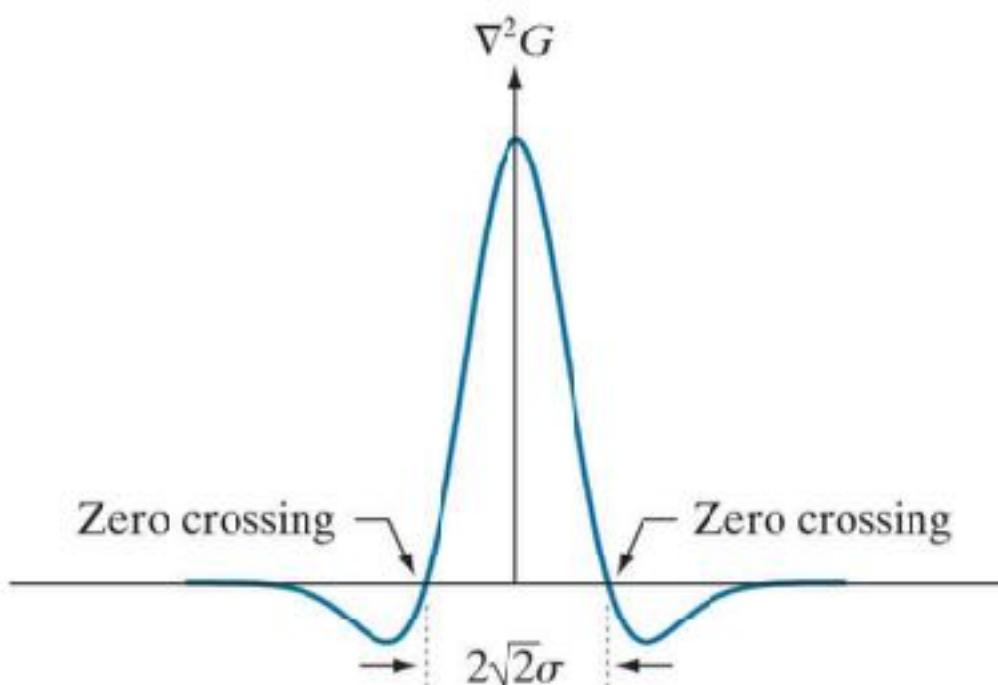


Canny edge detector

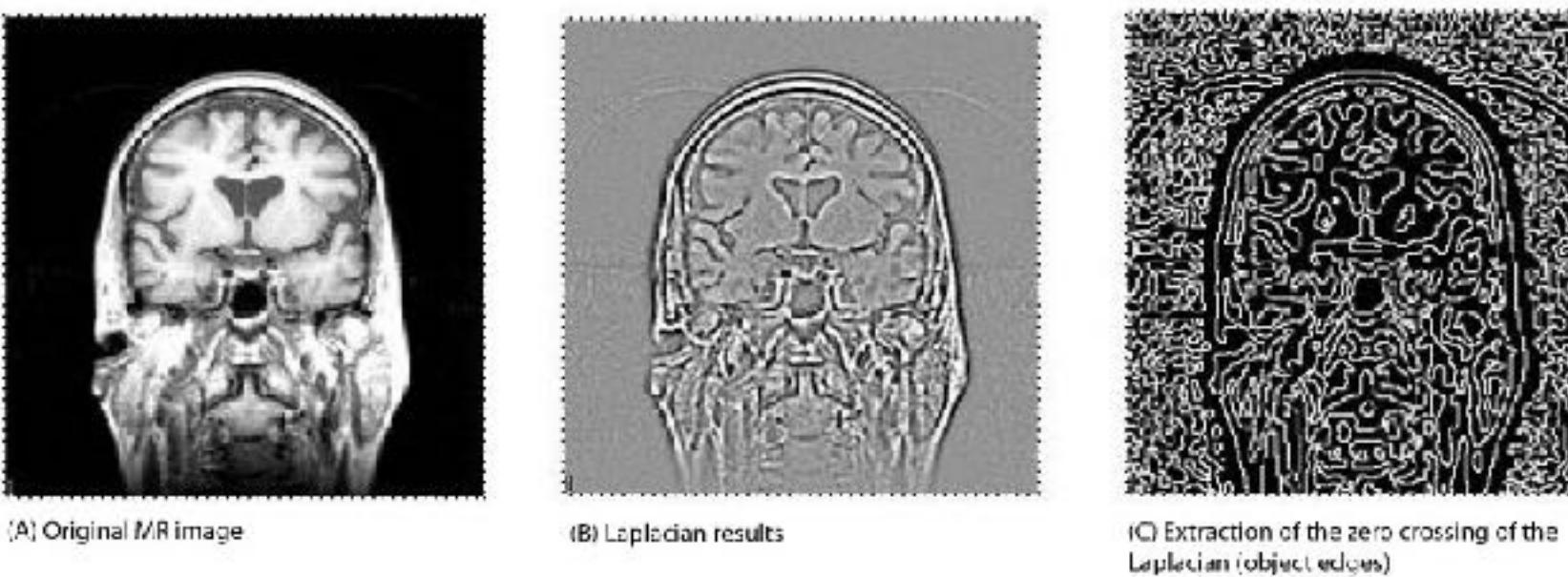


Figure 1: The cameraman image and its edges extracted

Laplacian/ DOG

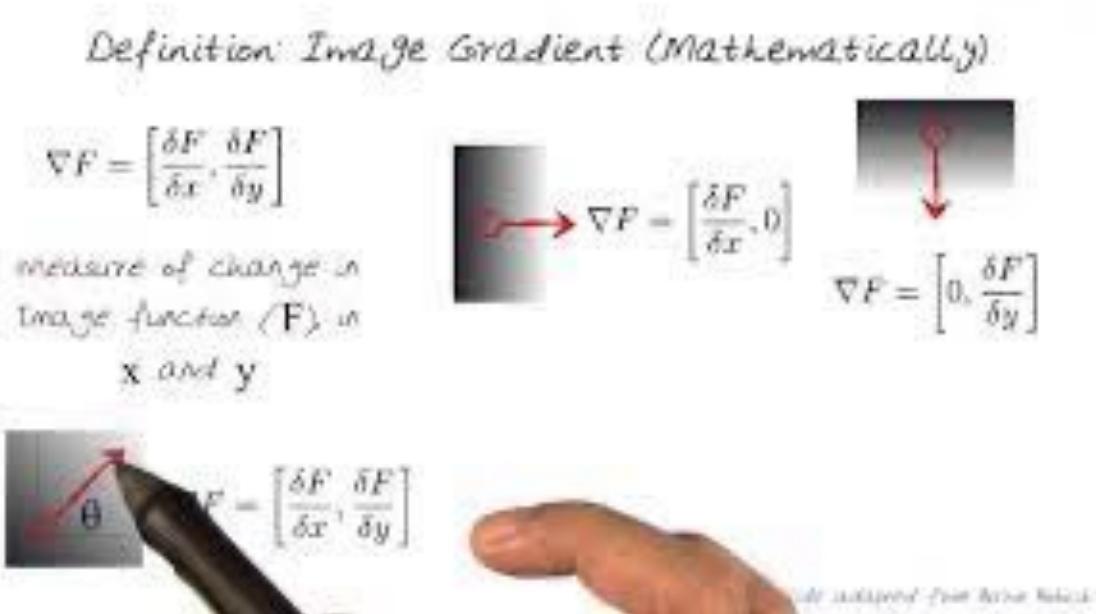


Laplacian zero crossings



Edge Detectors

Image gradients



Edge maps



Canny edge detector

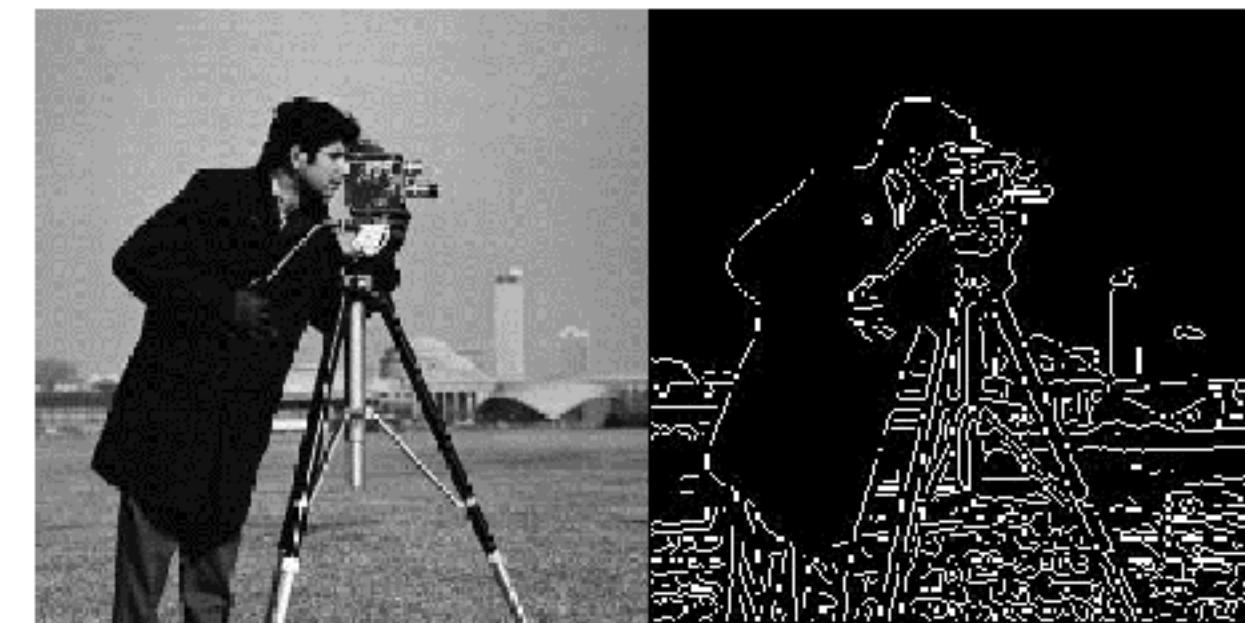
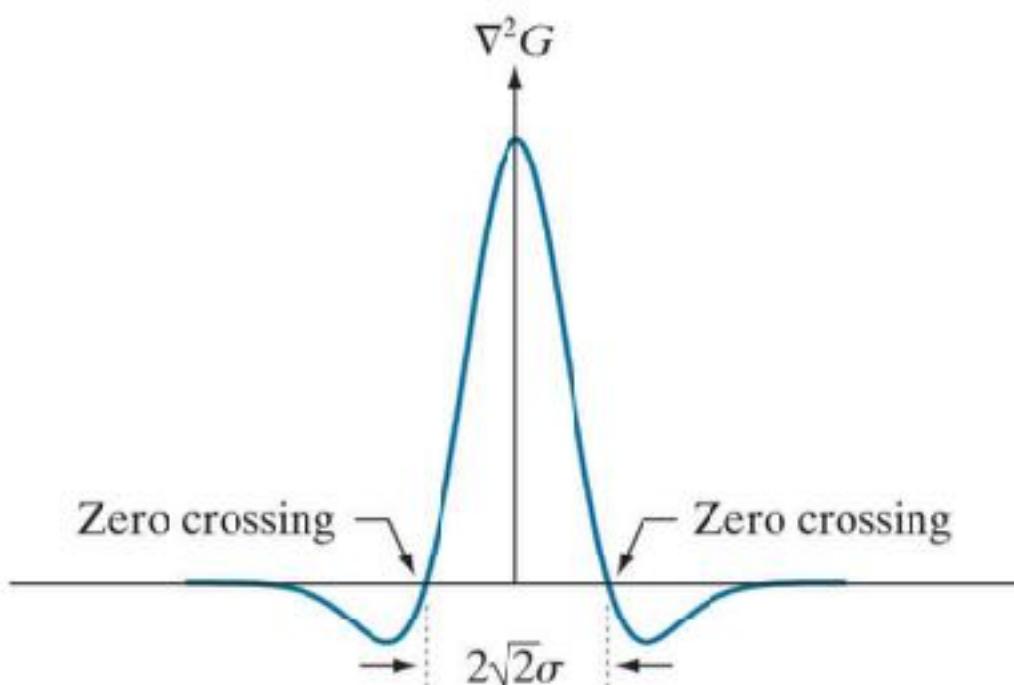


Figure 1: The cameraman image and its edges extracted

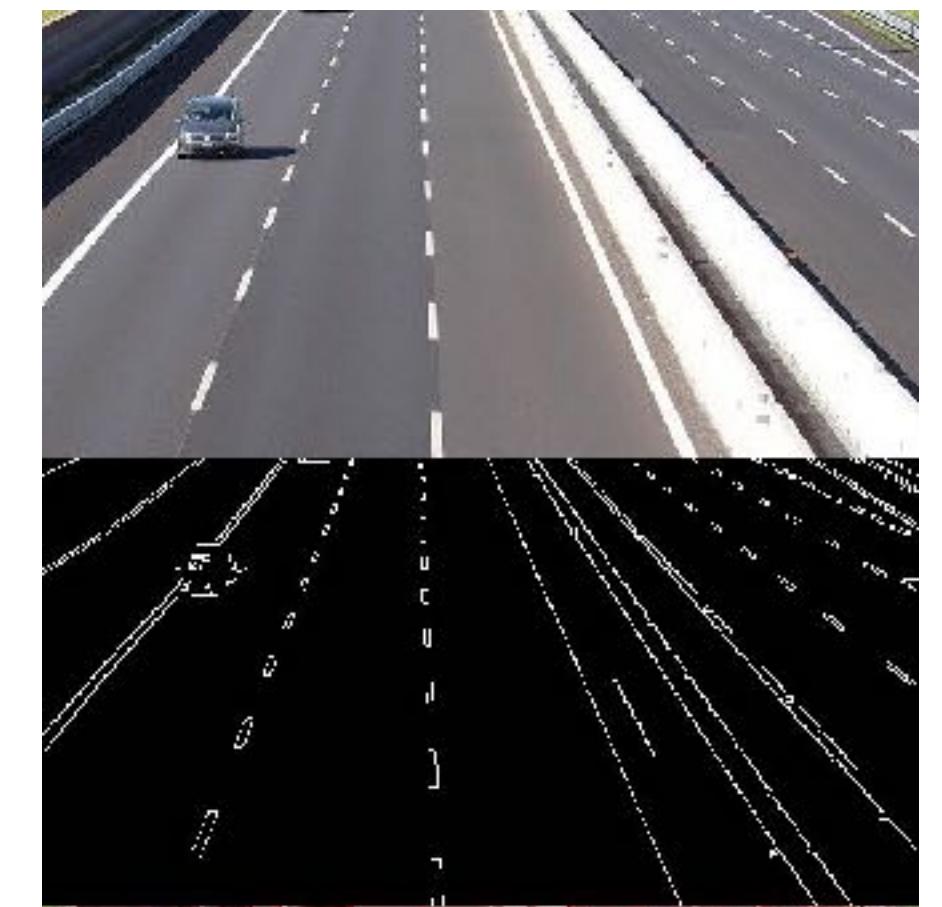
Laplacian/ DOG



Laplacian zero crossings



Hough transform



Corner Detector and Features

Corner Detector and Features

What are corners?

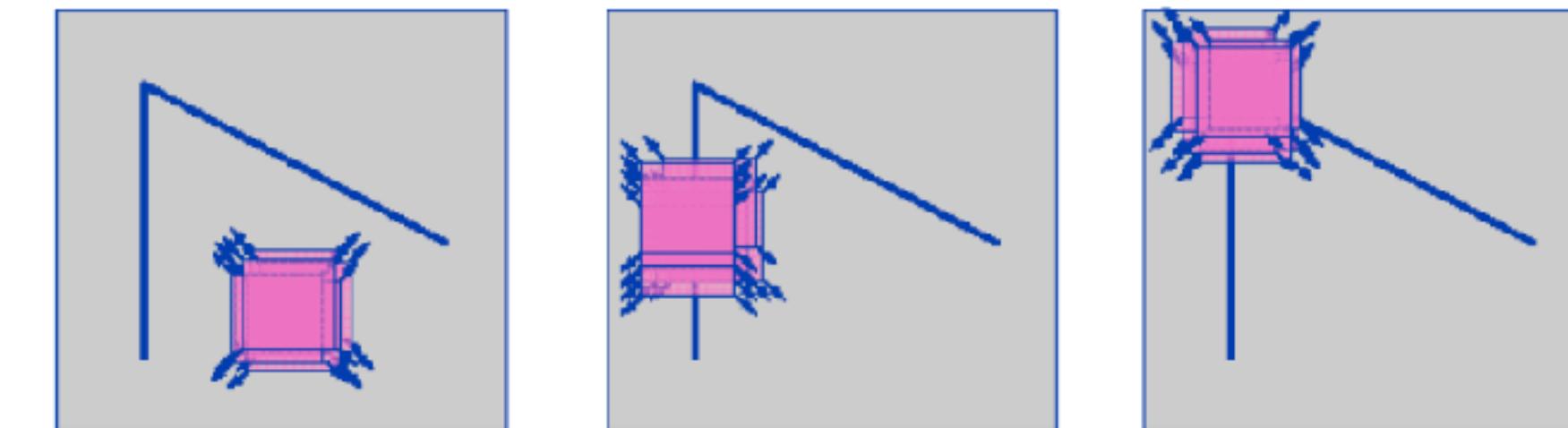


Corner Detector and Features

What are corners?



Auto-correlation



"flat" region:
no change in
all directions

"edge":
no change along
the edge direction

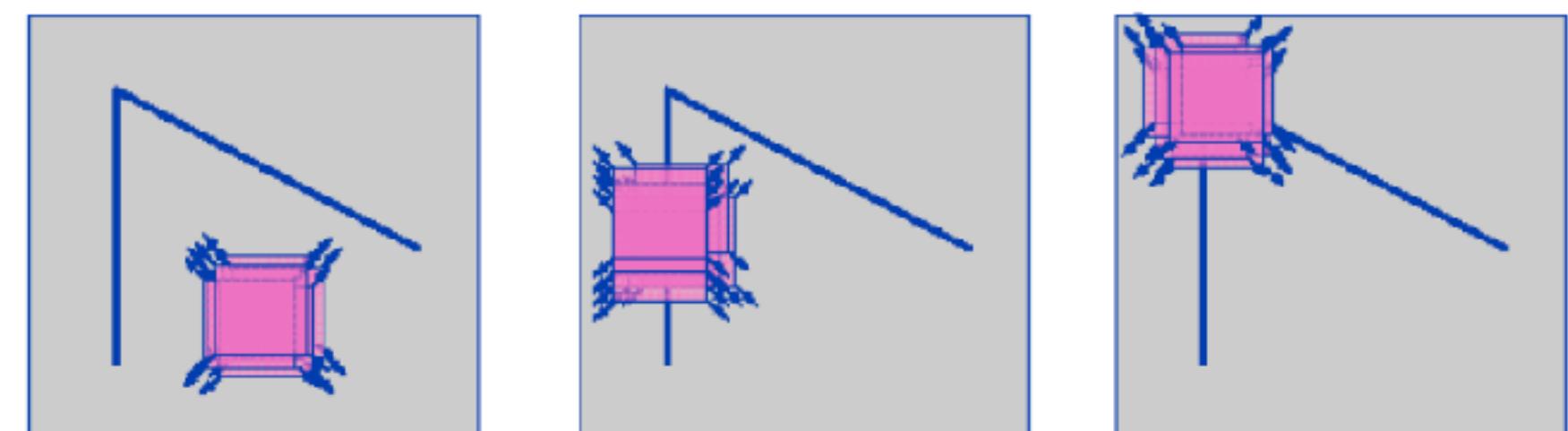
"corner":
significant change
in all directions

Corner Detector and Features

What are corners?



Auto-correlation



“flat” region:
no change in
all directions

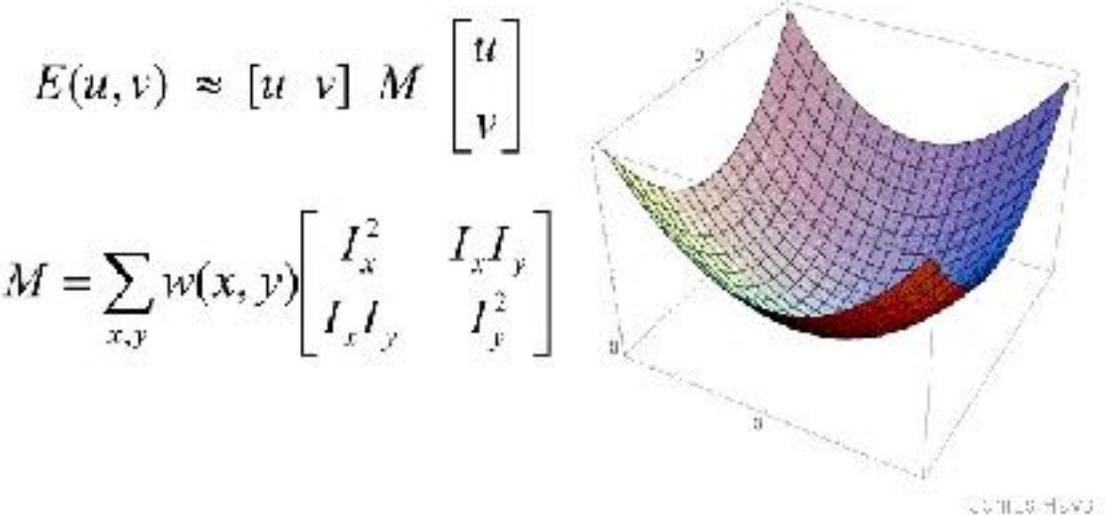
“edge”:
no change along
the edge direction

“corner”:
significant change
in all directions

Harris Corner Detector

Interpreting the second moment matrix

The surface $E(u,v)$ is locally approximated by a quadratic form. Let's try to understand its shape.

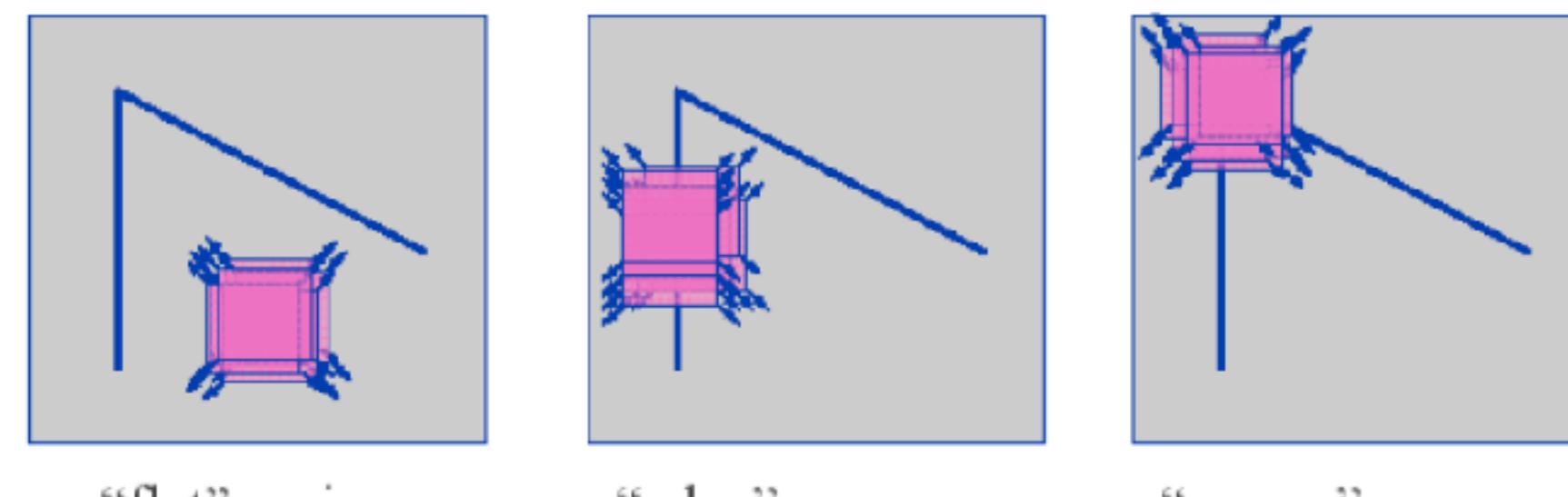


Corner Detector and Features

What are corners?



Auto-correlation



"flat" region:
no change in
all directions

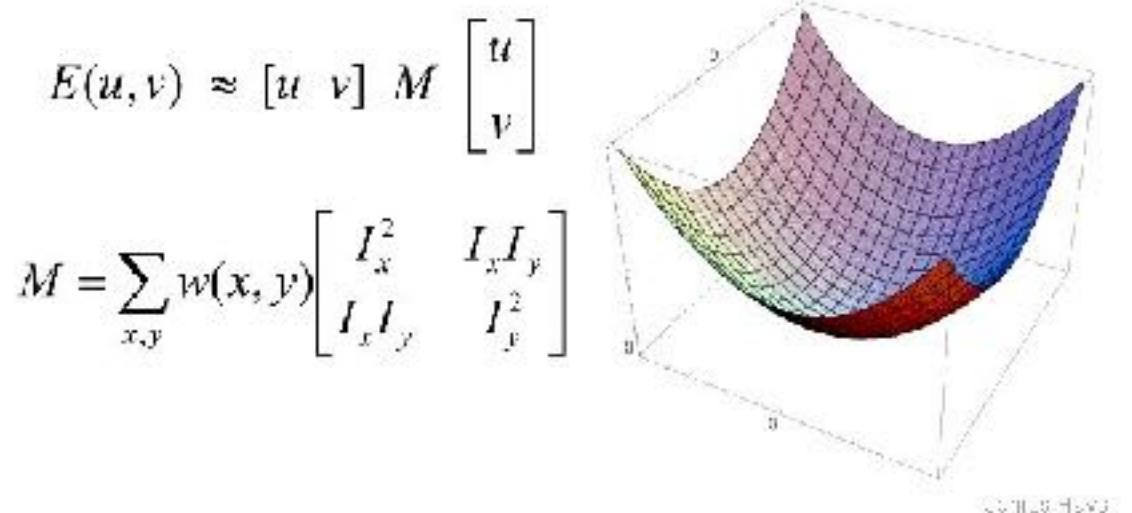
"edge":
no change along
the edge direction

"corner":
significant change
in all directions

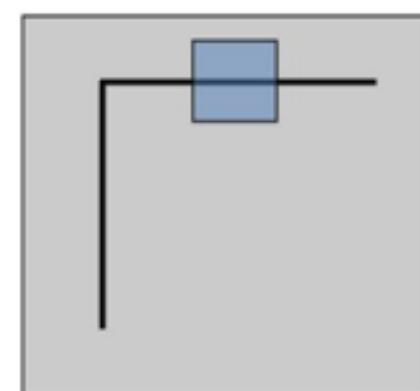
Harris Corner Detector

Interpreting the second moment matrix

The surface $E(u,v)$ is locally approximated by a quadratic form. Let's try to understand its shape.

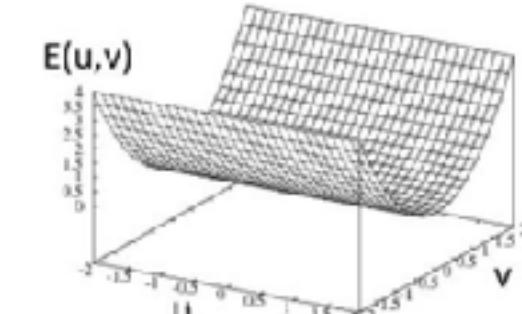


Harris Matrix Eigenvalues



$$H = \begin{bmatrix} 0 & 0 \\ 0 & C \end{bmatrix}$$

Horizontal edge: $I_x = 0$

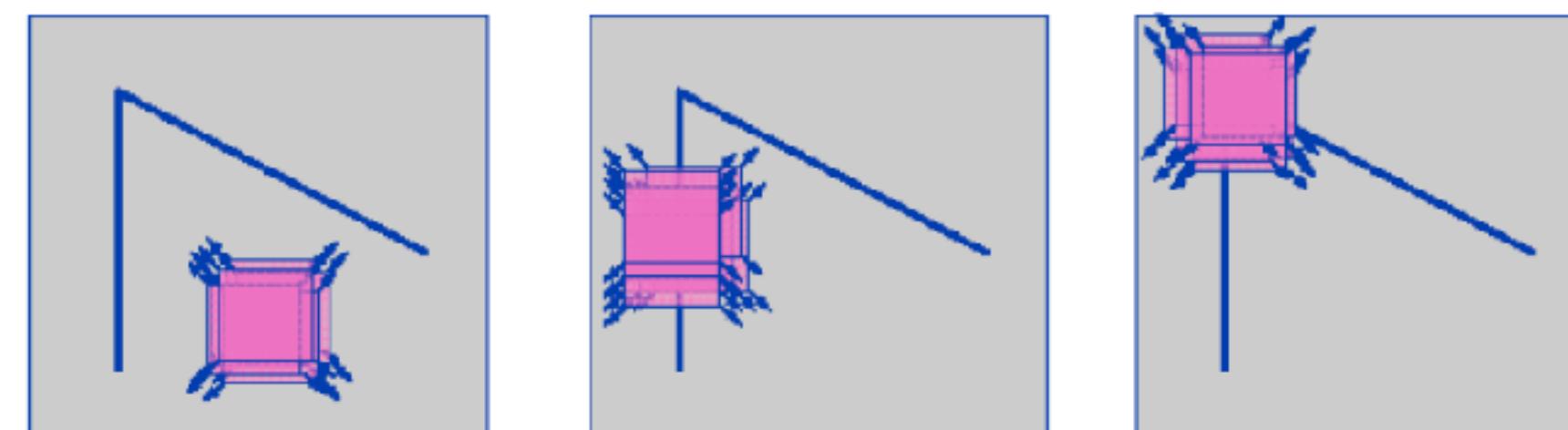


Corner Detector and Features

What are corners?



Auto-correlation



“flat” region:
no change in
all directions

“edge”:
no change along
the edge direction

“corner”:
significant change
in all directions

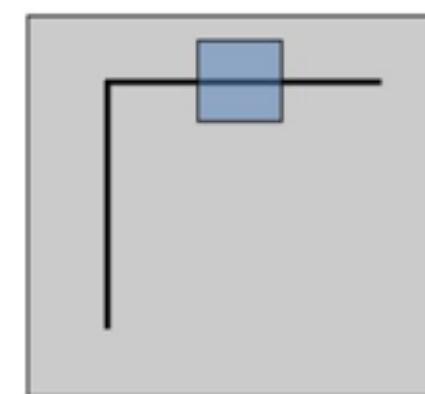
Harris Corner Detector

Interpreting the second moment matrix

The surface $E(u,v)$ is locally approximated by a quadratic form. Let's try to understand its shape.

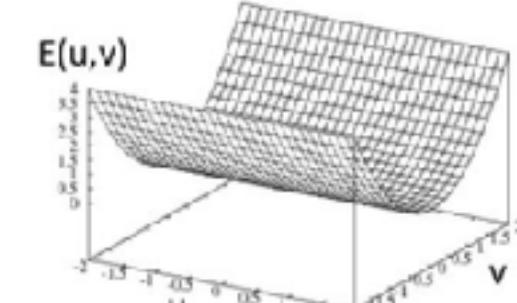
$$E(u,v) \approx [u \ v] M \begin{bmatrix} u \\ v \end{bmatrix}$$
$$M = \sum_{x,y} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix}$$
A 3D surface plot showing a paraboloid opening upwards, representing the surface $E(u,v)$. The axes are labeled u and v , and the vertical axis represents the value of the surface.

Harris Matrix Eigenvalues

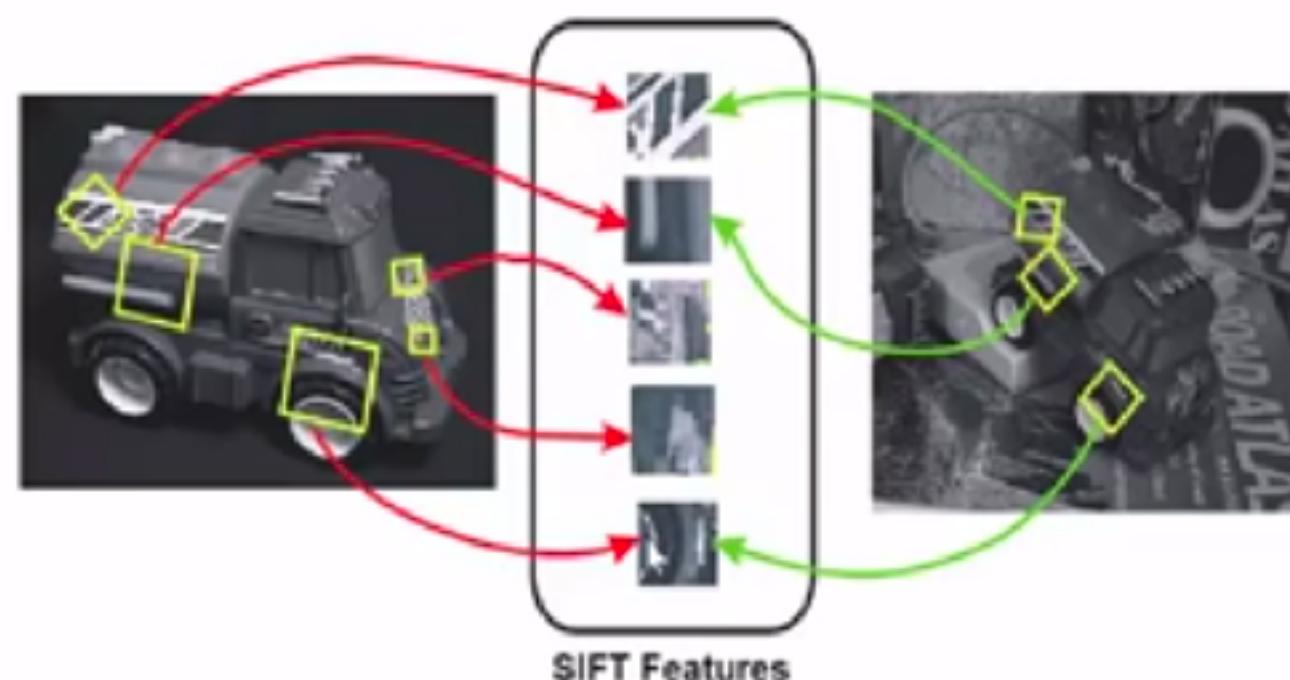


$$H = \begin{bmatrix} 0 & 0 \\ 0 & C \end{bmatrix}$$

Horizontal edge: $I_x = 0$



SIFT

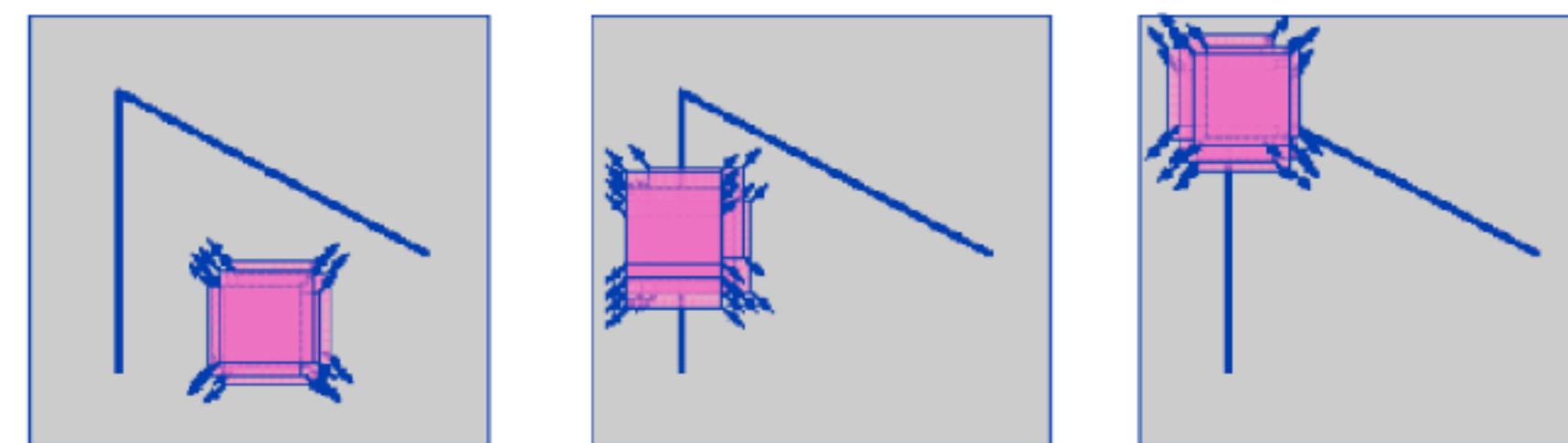


Corner Detector and Features

What are corners?



Auto-correlation



“flat” region:
no change in
all directions

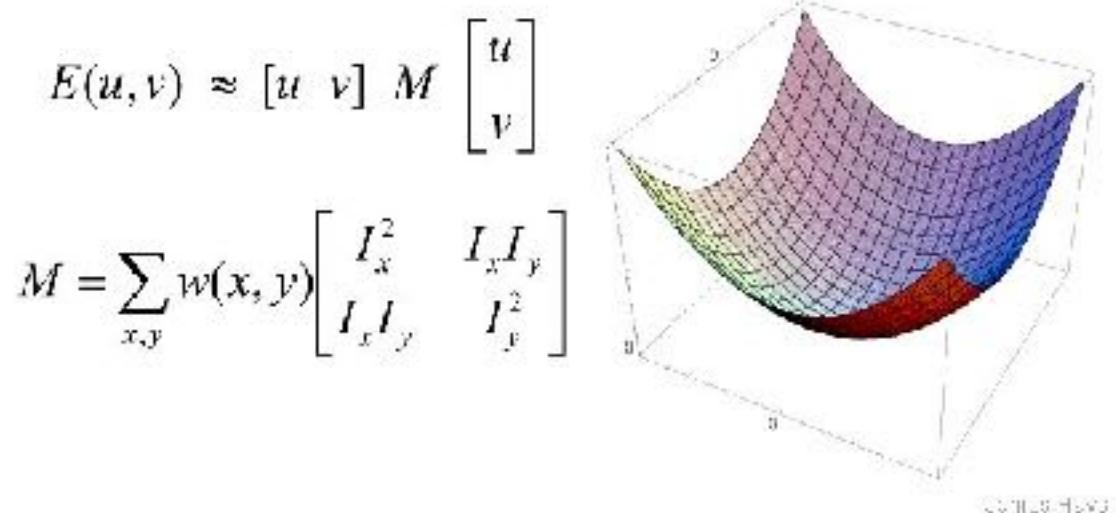
“edge”:
no change along
the edge direction

“corner”:
significant change
in all directions

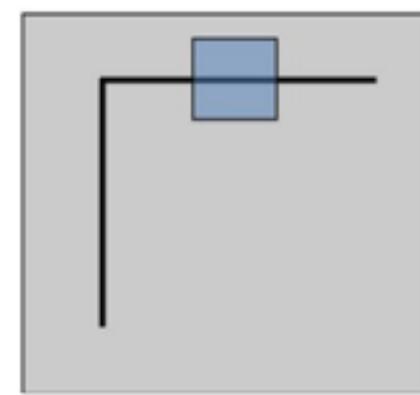
Harris Corner Detector

Interpreting the second moment matrix

The surface $E(u,v)$ is locally approximated by a quadratic form. Let's try to understand its shape.

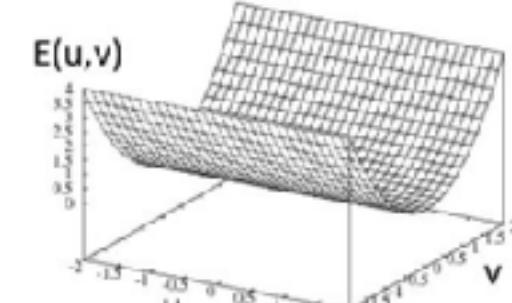


Harris Matrix Eigenvalues

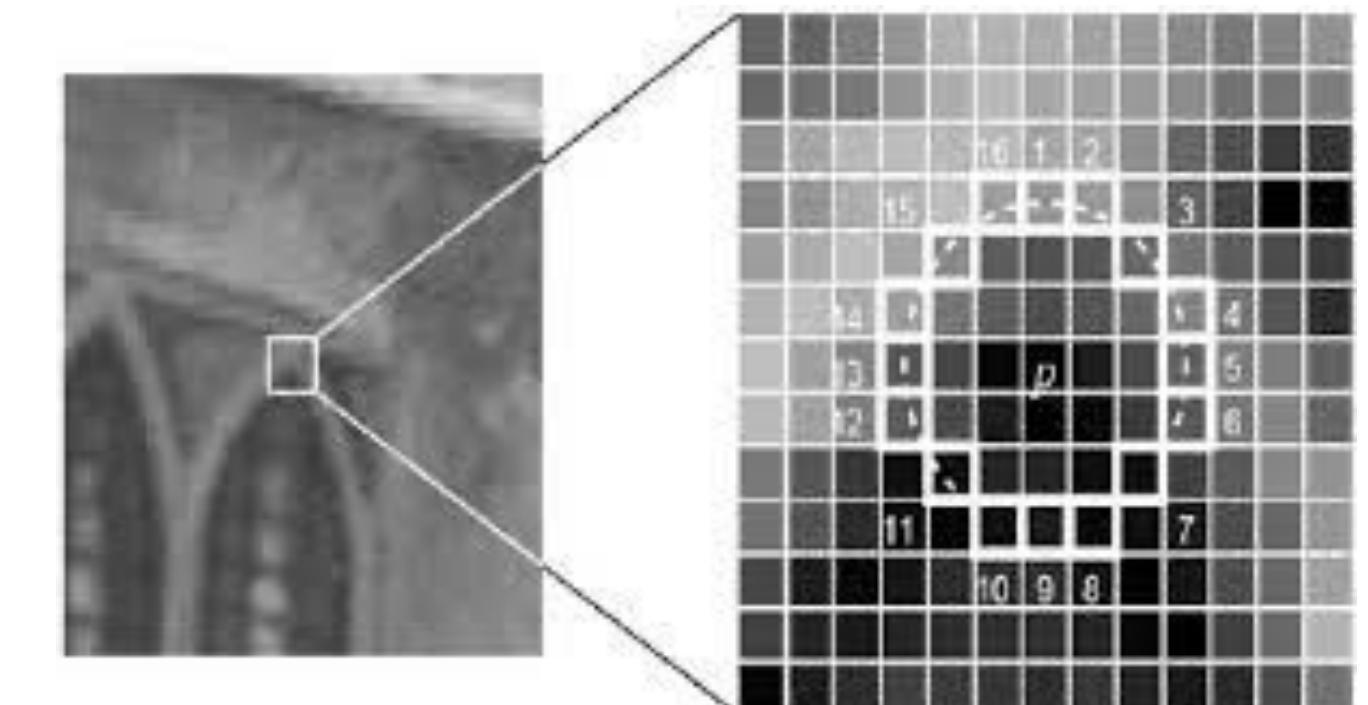
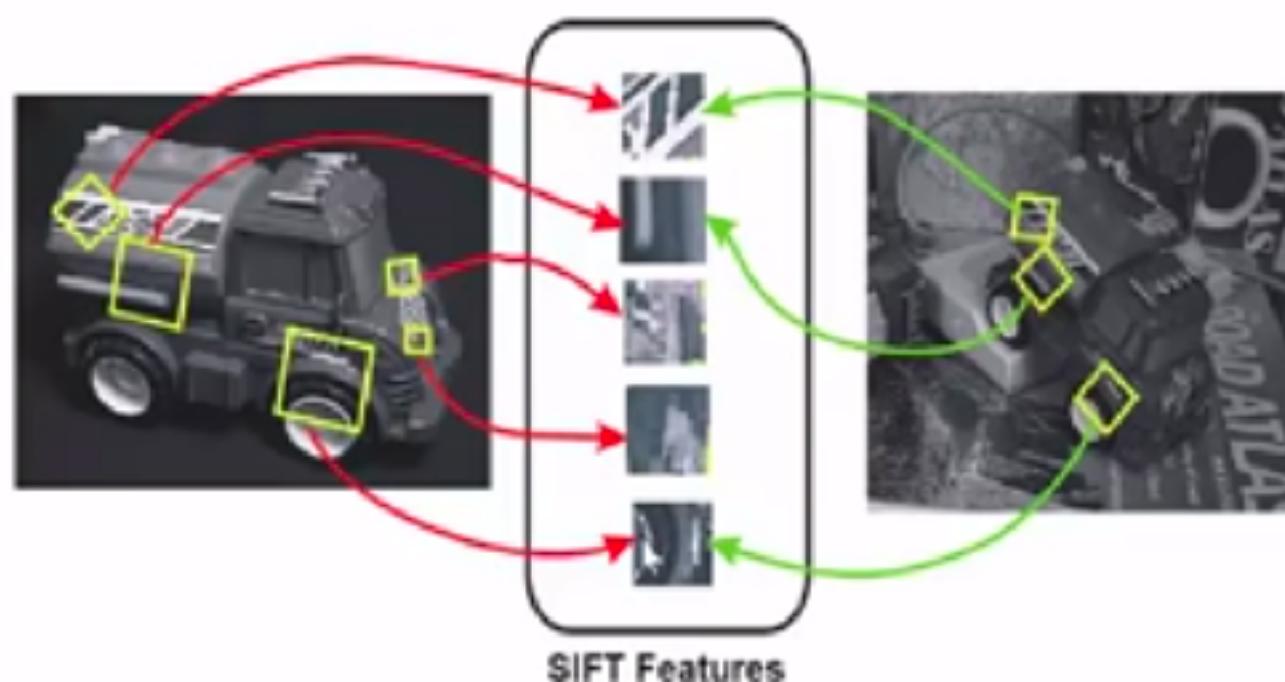


$$H = \begin{bmatrix} 0 & 0 \\ 0 & C \end{bmatrix}$$

Horizontal edge: $I_x = 0$



SIFT



Susan/Fast

Image Matching

Image Matching

Template matching and tracking

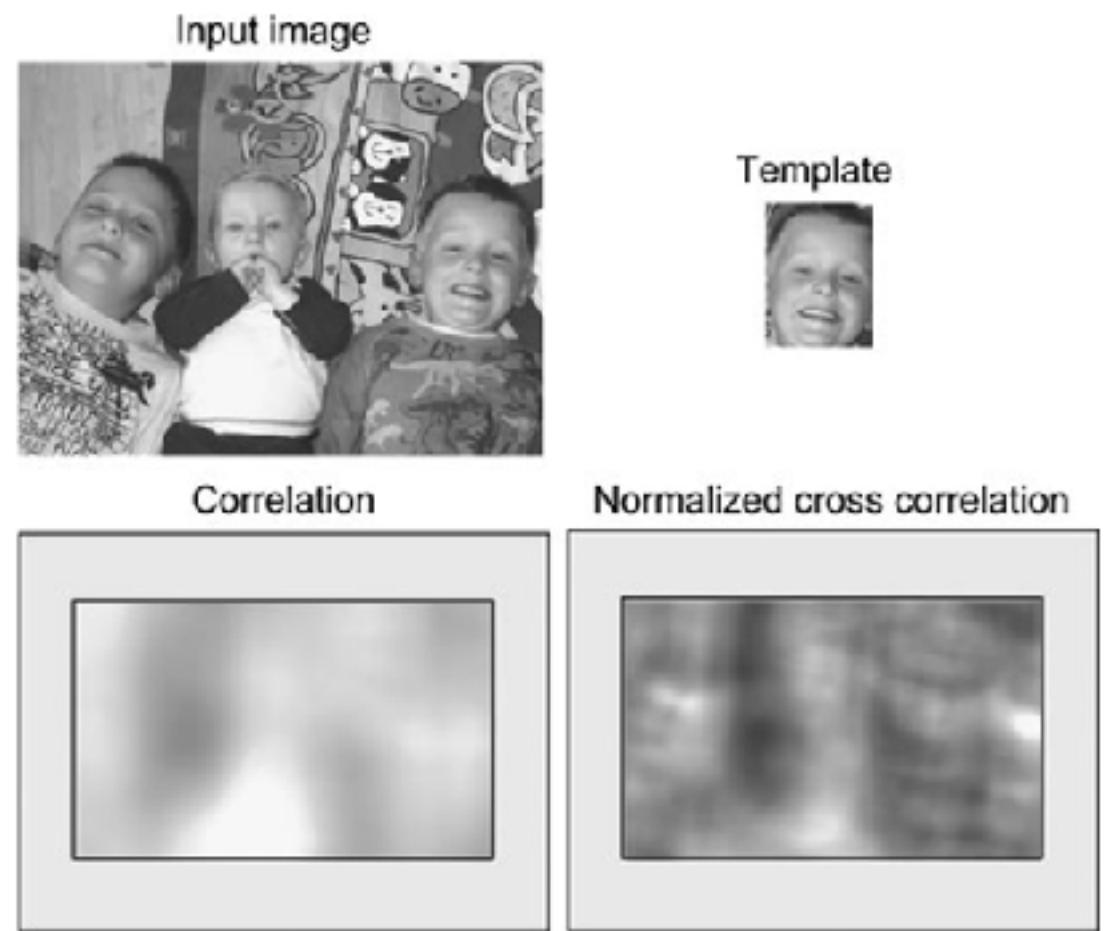


Image Matching

Template matching and tracking

SSD/NCC

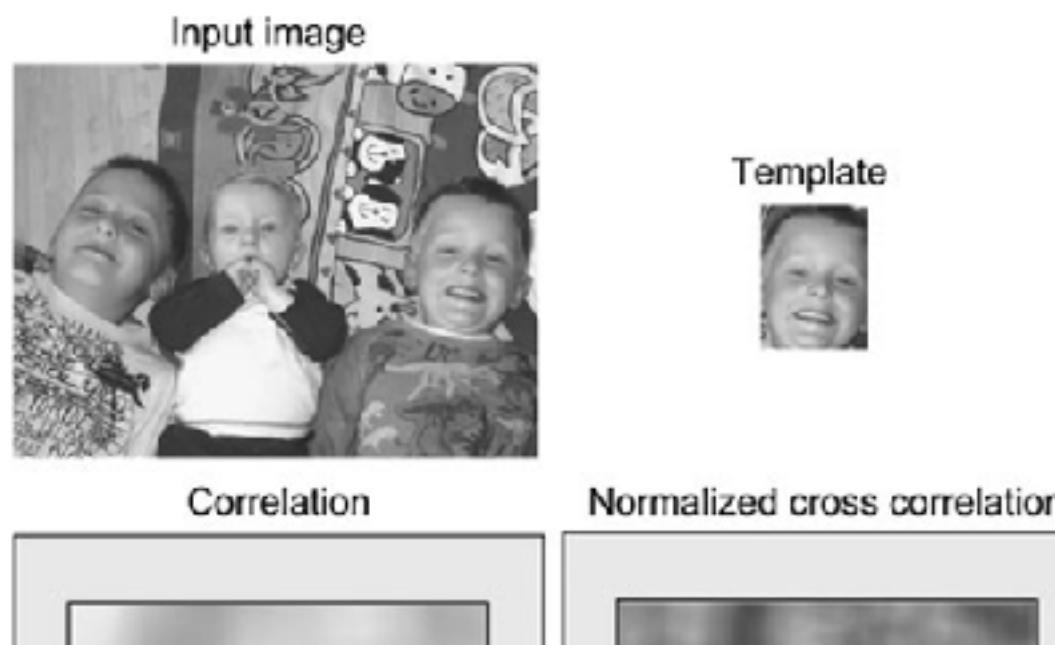


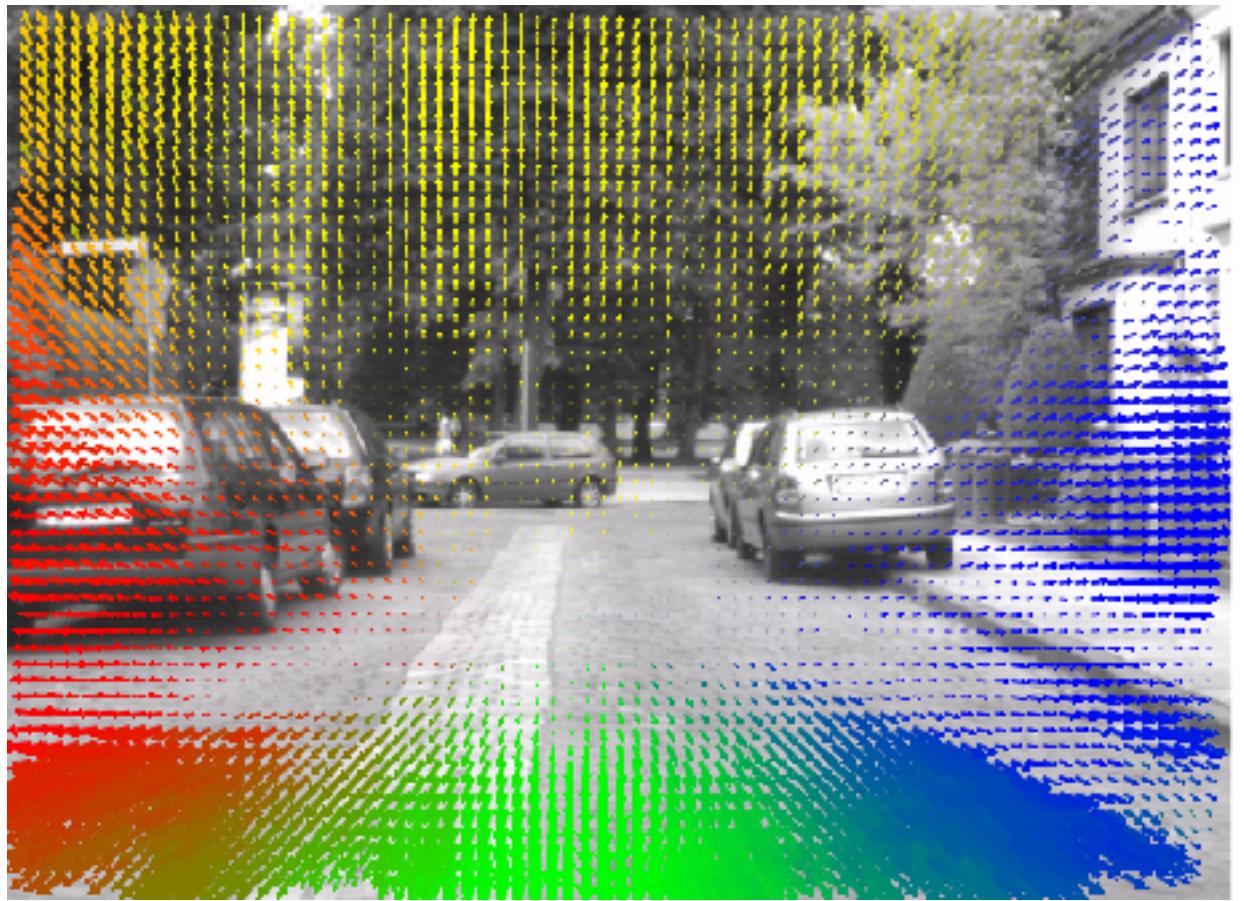
Image similarity

Name	Measure	Toolbox function
SAD	$s = \sum_{(u,v) \in I} \mathbf{I}_1[u, v] - \mathbf{I}_2[u, v] $	sad()
SSD	$s = \sum_{(u,v) \in I} (\mathbf{I}_1[u, v] - \mathbf{I}_2[u, v])^2$	ssd()
ZNCC	$s = \frac{\sum_{(u,v) \in I} \mathbf{I}_1[u, v] \cdot \mathbf{I}_2[u, v]}{\sqrt{\sum_{(u,v) \in I} \mathbf{I}_1^2[u, v] \cdot \sum_{(u,v) \in I} \mathbf{I}_2^2[u, v]}}$	zncc()

Optical Flow

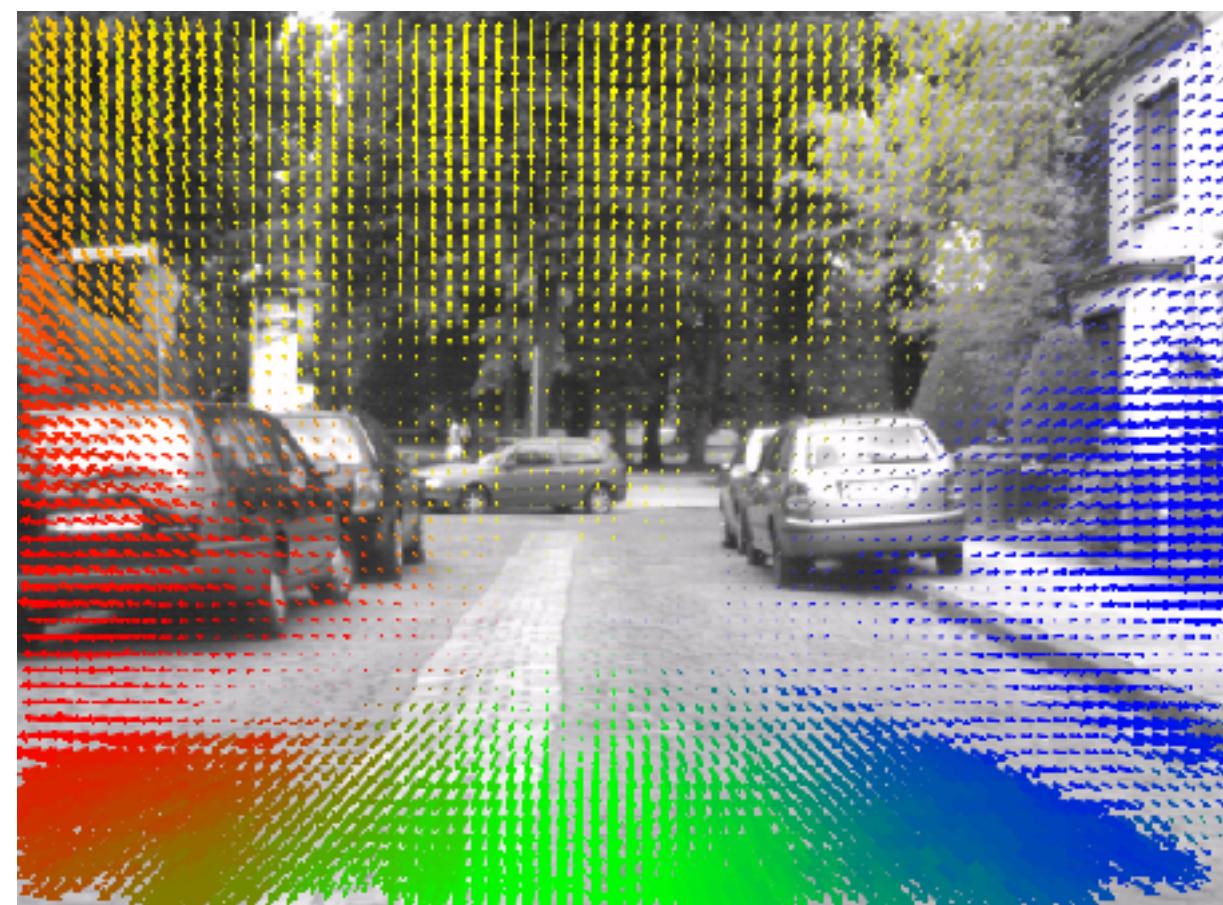
Optical Flow

Problem setup



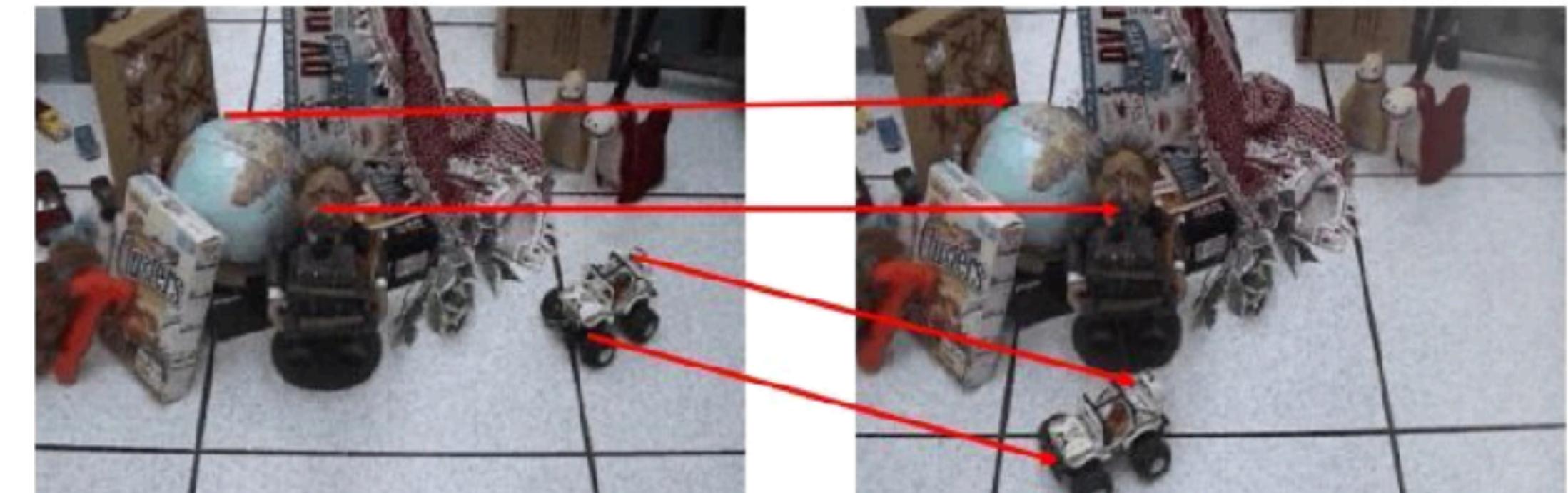
Optical Flow

Problem setup



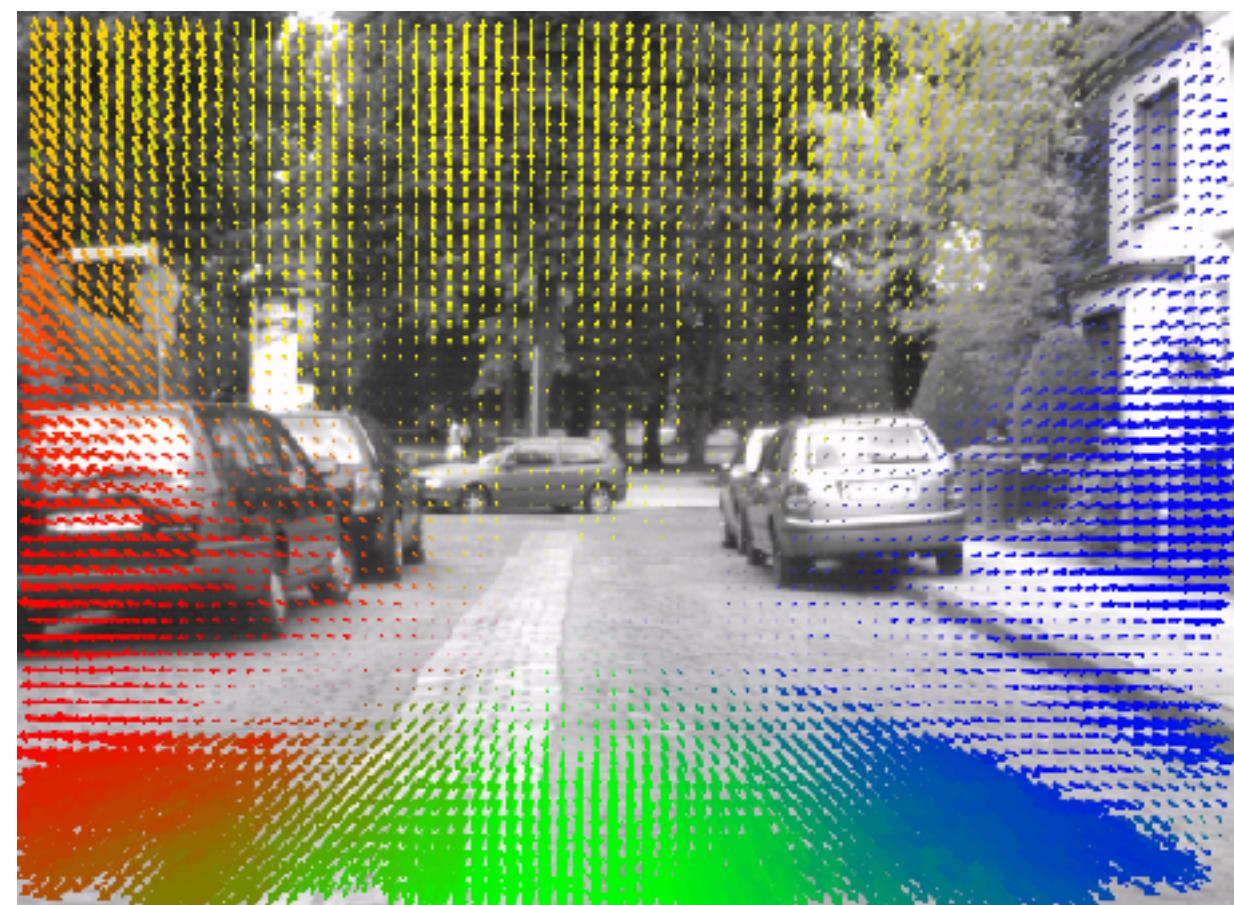
Brightness constancy

Where did each pixel in image 1 go to in image 2



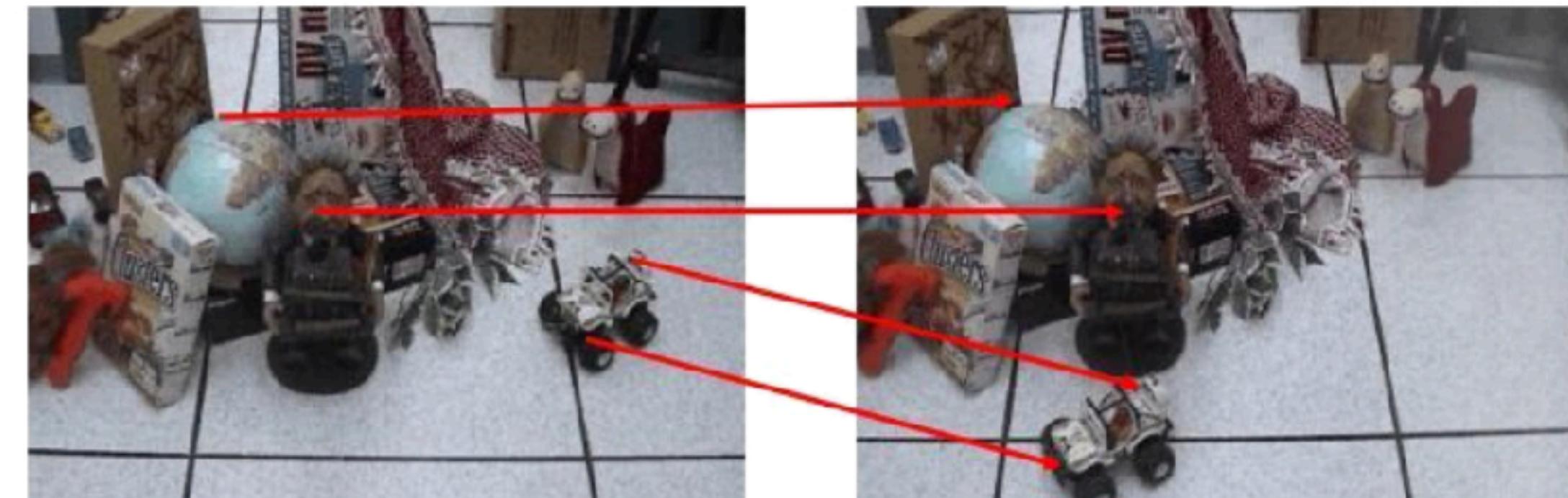
Optical Flow

Problem setup

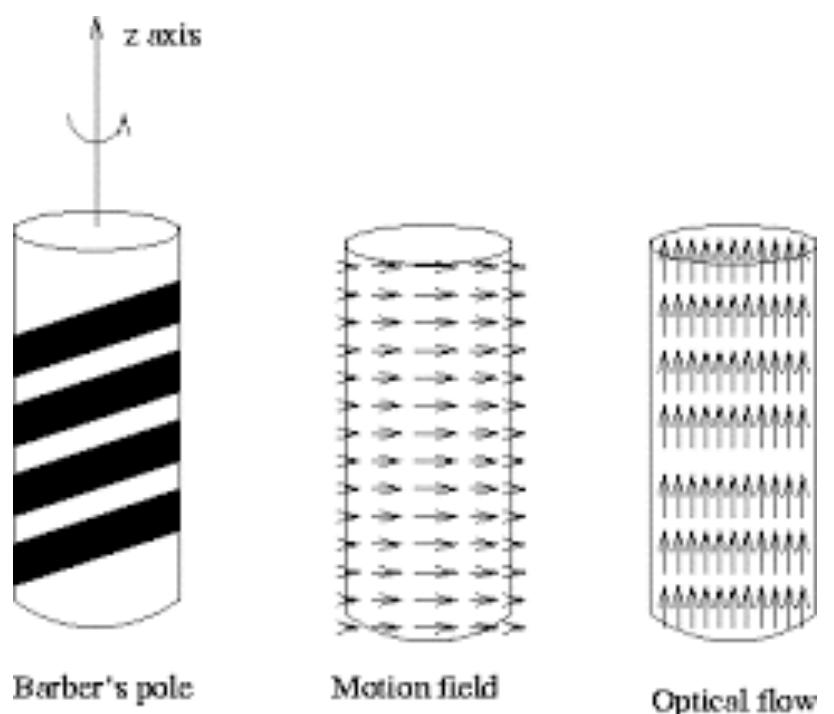


Brightness constancy

Where did each pixel in image 1 go to in image 2

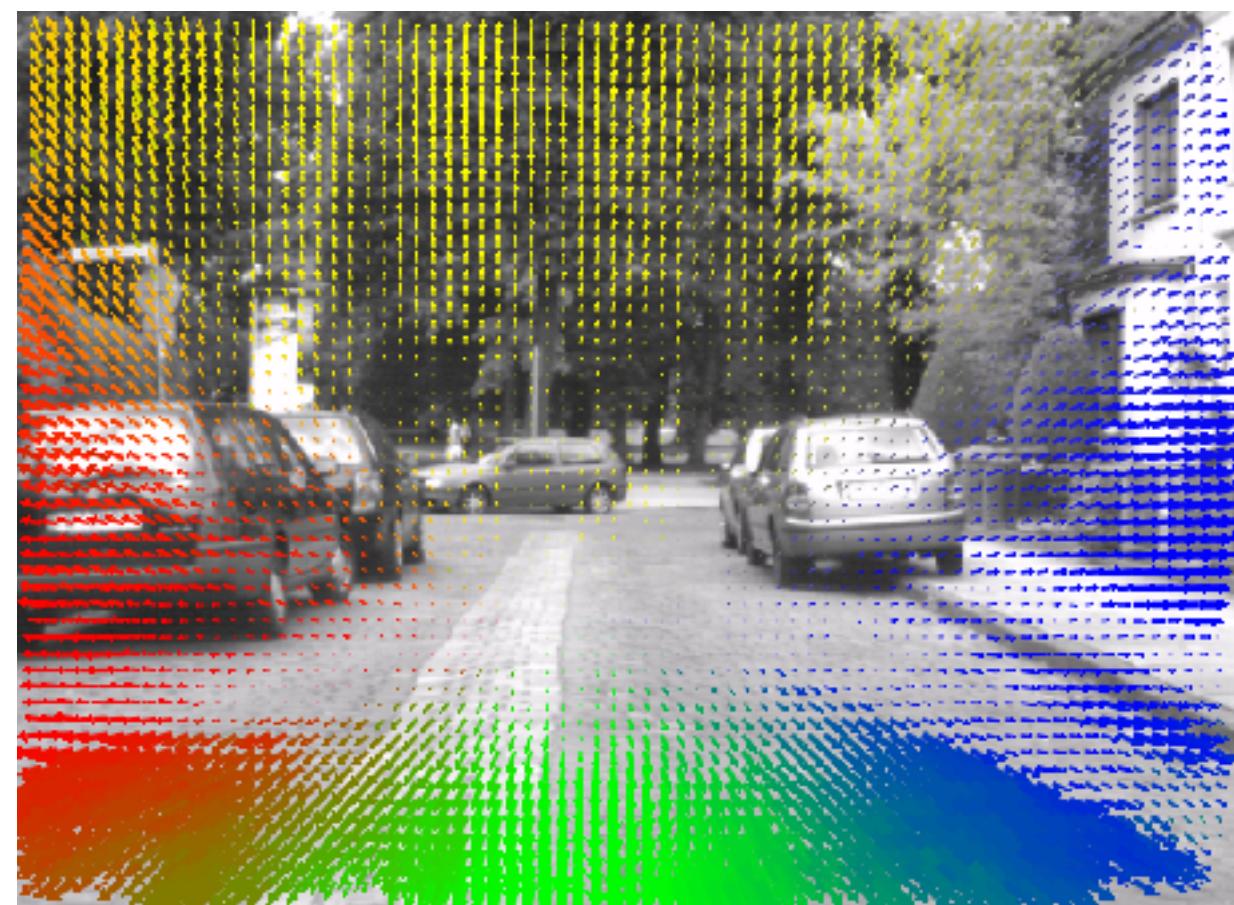


Aperture problem



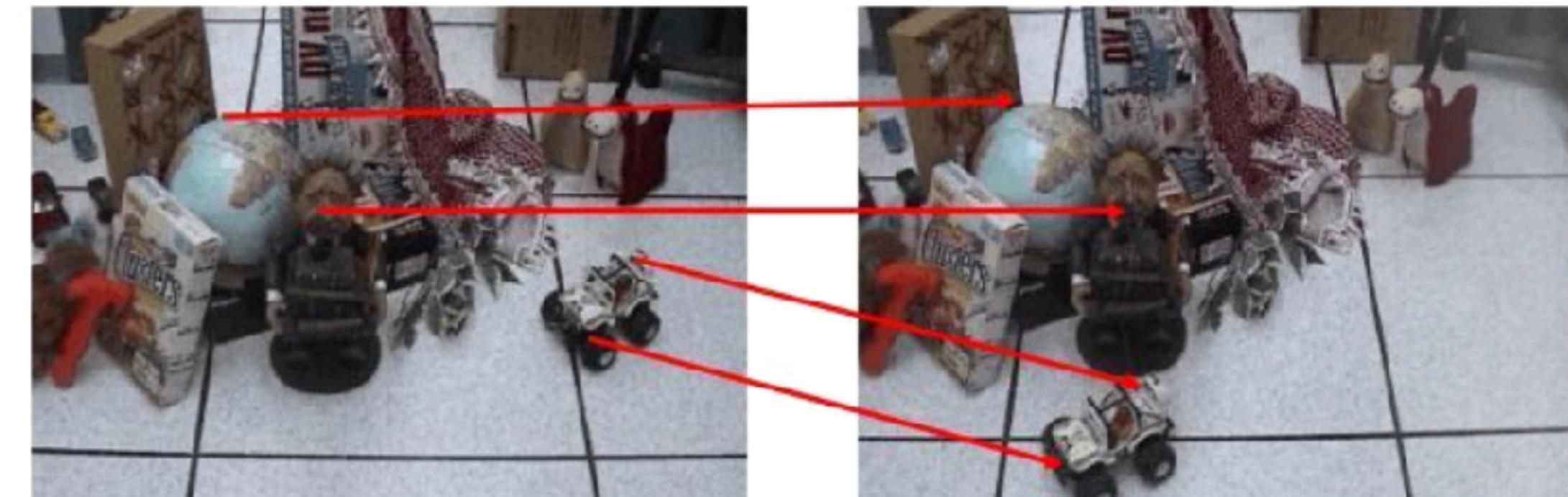
Optical Flow

Problem setup

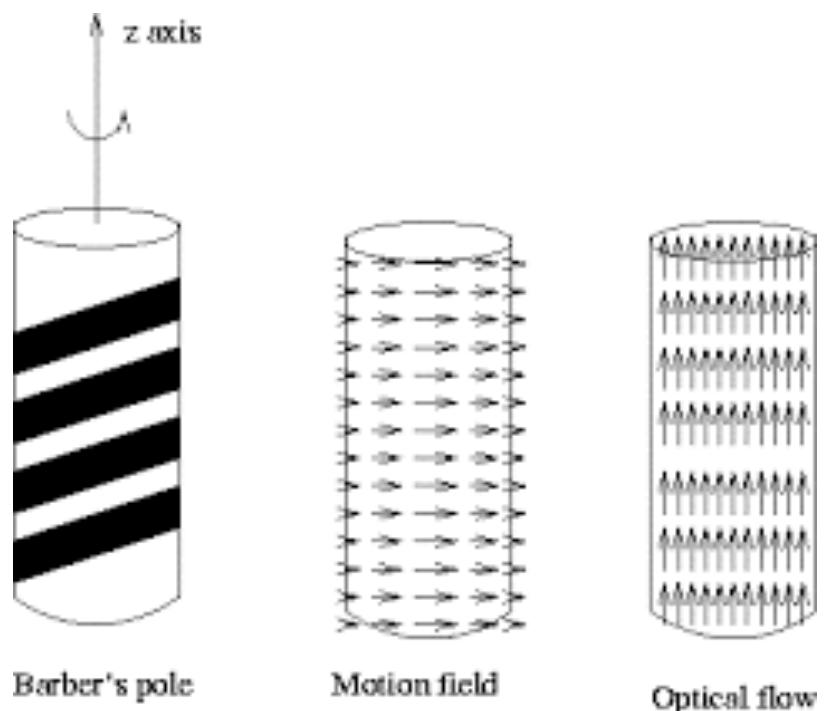


Brightness constancy

Where did each pixel in image 1 go to in image 2



Aperture problem

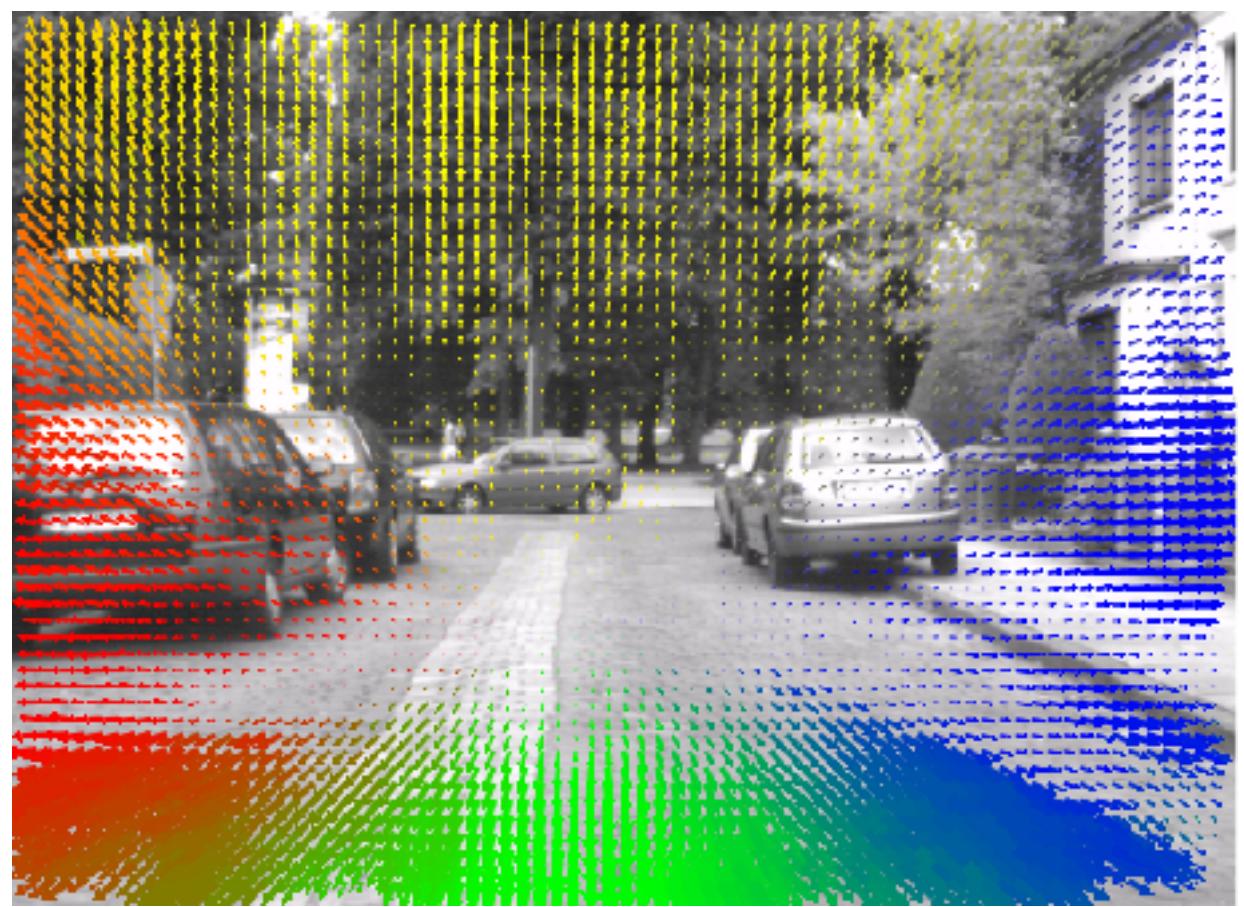


Optical flow equation

$$\frac{dI}{dx}u + \frac{dI}{dy}v + \frac{dI}{dt} = 0$$

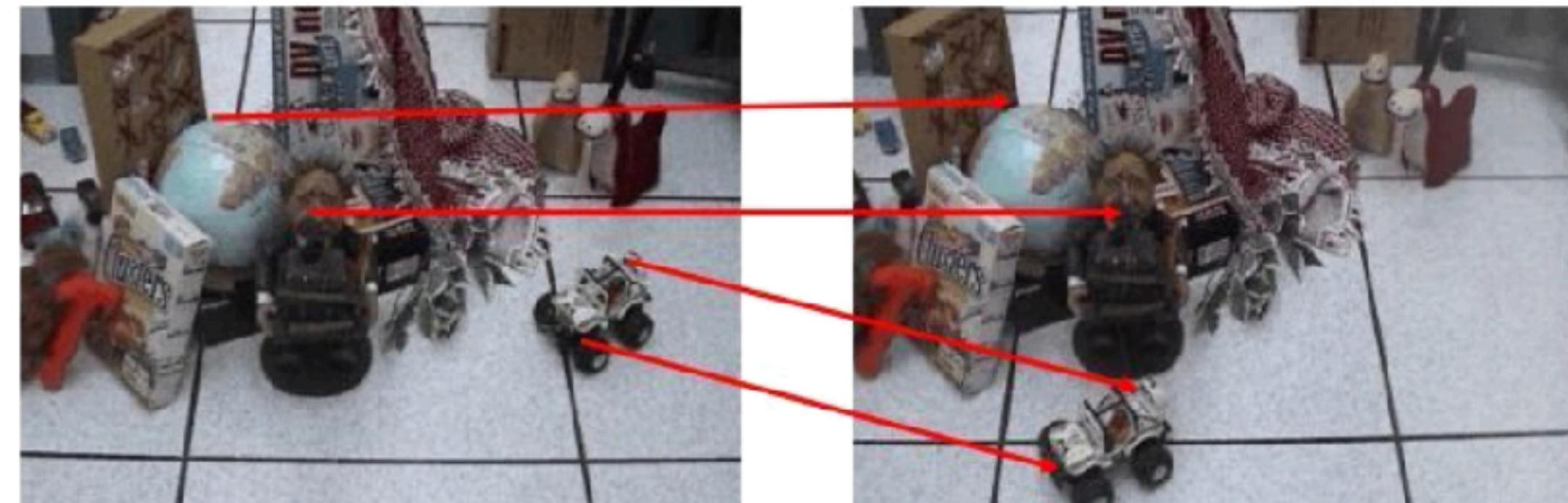
Optical Flow

Problem setup

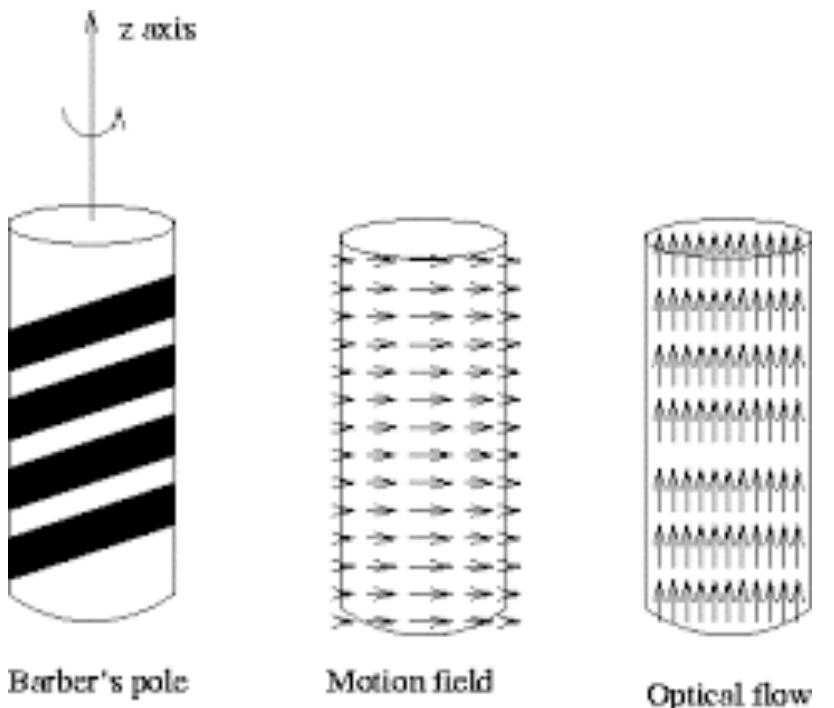


Brightness constancy

Where did each pixel in image 1 go to in image 2



Aperture problem



Optical flow equation

$$\frac{dI}{dx}u + \frac{dI}{dy}v + \frac{dI}{dt} = 0$$

Lucas-Kanade algorithm



Two-way Communication

Two-way Communication

- I am teaching this course after 10 years!
- Our aim is to introduce you to the world of **Image Processing**

Two-way Communication

- I am teaching this course after 10 years!
- Our aim is to introduce you to the world of **Image Processing**
- You are invited/encouraged to give feedback

Two-way Communication

- I am teaching this course after 10 years!
- Our aim is to introduce you to the world of **Image Processing**
- You are invited/encouraged to give feedback
 - On-line forum (via Moodle)
 - Speak up. Please send us your criticism/comments/suggestions
 - Ask questions, please!
- Thanks to many people who helped so far with slides/comments

People



Niloy Mitra



Tobias Ritschel

**Mirgahney Mohammed
Daniele Giunchi
Hengyi Wang**

Timetable

- **Thursday 10:00-11:00 (Anatomy G04 Gavin de Beer LT)**
- **Friday 11:00-13:00 (Chadwick G07)**
- **Lab session Thursday 16:00-18:00**

Course Logistics

- **Lectures + QA sessions + lab sessions**
- **Grading: 2 courseworks (10% + 10%)**
(date to be announced)
- **Project (80%)**
- **Expect to spend a lot of time on this course.**
Rewarding but we need your participation and sustained effort.
- **Lecture slides and video — available on Moodle**
- **Reachable via email**