CNN for CV

AI for CV Group
2020

Week 2.
What Is CV

Outline:

I. Convolution & Applications (Low Level)
A. Low Level Image Processing (Part II)
B. Applications

II. Feature Points (Mid Level)
C. What Is A Feature Point
D. Corner Point
E. SIFT

III. Classical CV Procedure (High Level)
F. Classification In Classical CV Procedure

I. Conv & App

(Low Level)

I. Convolution & Applications

A. Low Level Image Processing

A1. 1-dim convolution

I. Convolution & Applications

A. Low Level Image Processing

A2. 2-dim convolution

I. Convolution & Applications

A. Low Level Image Processing

A3. Image convolution

I. Convolution & Applications

Q.As for convolution

1. Do I have to turn over the kernel?

$$y(n) = \sum_{i=-\infty}^{\infty} x(i)h(n-i) = x(n) * h(n)$$

I. Convolution & Applications

Q.As for convolution

2. What can it do?

- First-order derivative

- Second-order derivative

I. Convolution & Applications

Q.As for convolution

2. What can it do?

- Response of first & second order derivative

- Conclusions

I. Convolution & Applications

Q.As for convolution

2. What can it do?

- Gaussian Kernel

- Acceleration

I. Convolution & Applications

Q. As for convolution

3. Applications

- Image Sharpening: Laplacian

- Edge Detection: Sobel

- Image Blurring: Median/Gaussian

- **Reading: [Bilateral Filtering](#)**

II. Feature Points
(Mid Level)

II. Feature Points

Why we need feature points?

What is a feature point?

What is a good feature point?

What is the form of a feature point?

How to get a feature point?

How many types of feature points?

Any applications?

......

II. Feature Points

Why we need feature points?

CV → stitching/classification/reconstruction...

↓

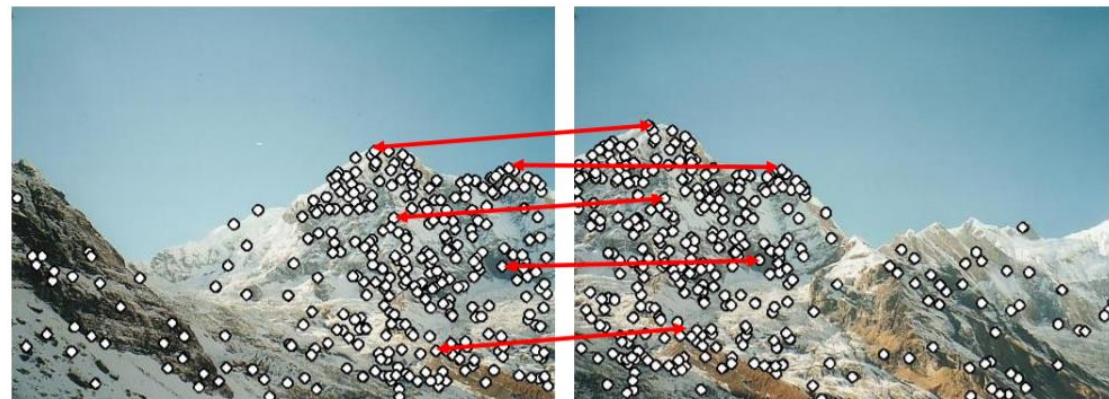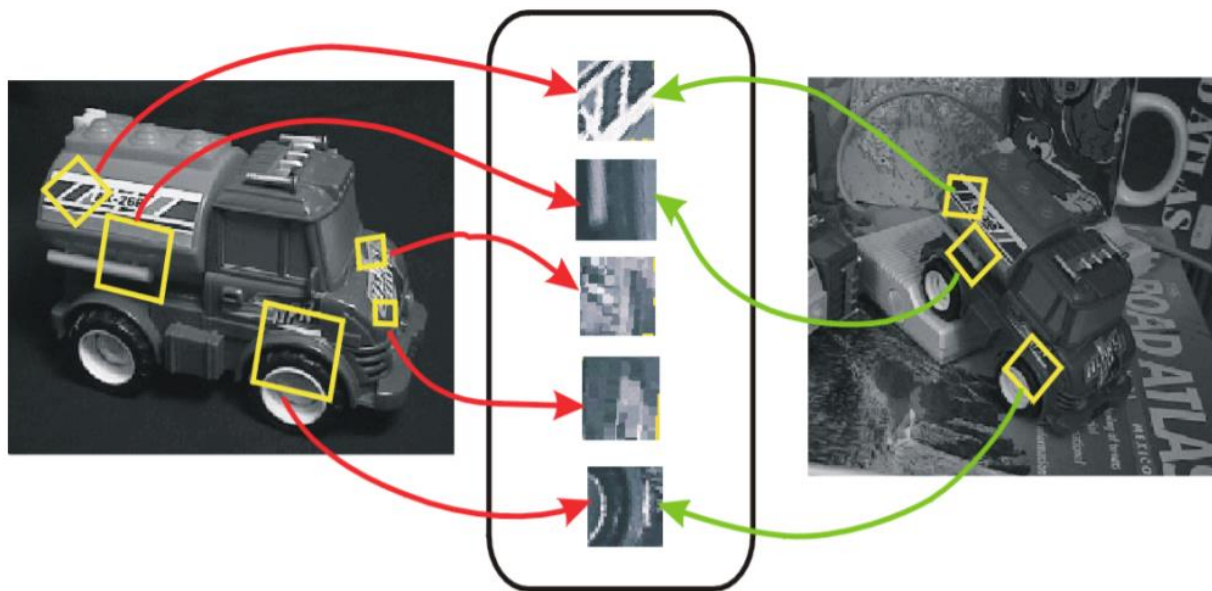↗　　　　look for pixels/objects representation

↙

feature points

II. Feature Points

What is a feature point?

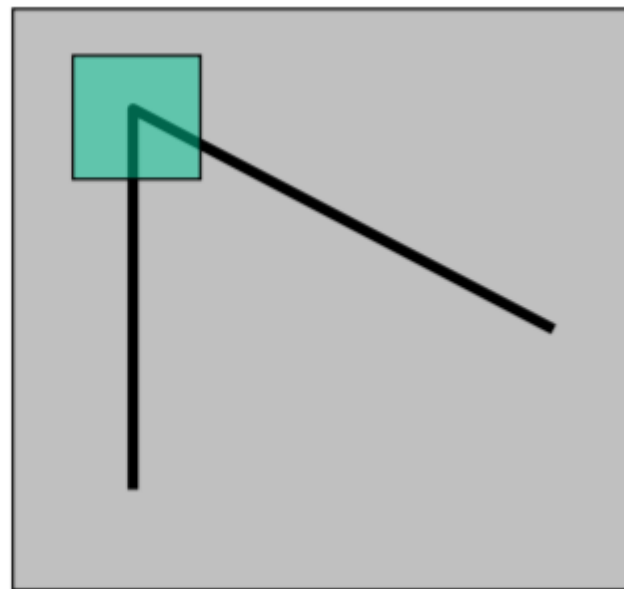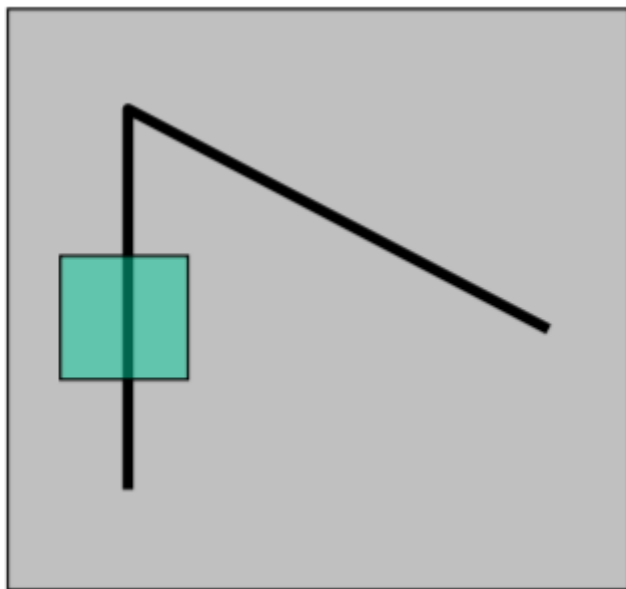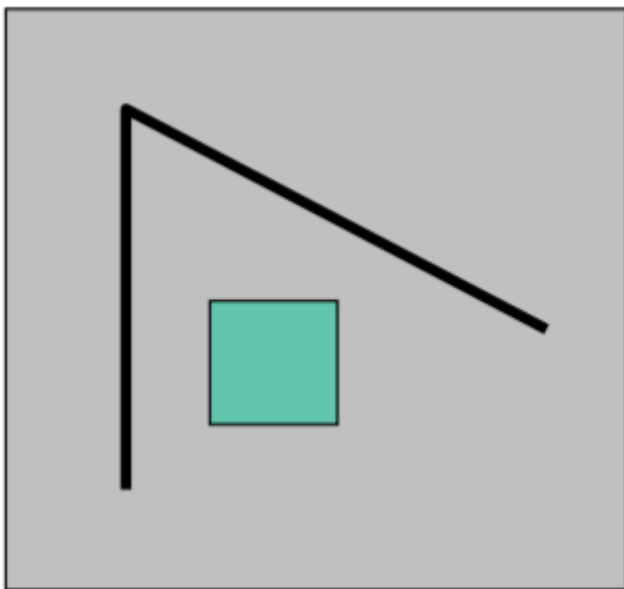Represents of objects/pixels

II. Feature Points

What is a good feature point?

- Very informational

II. Feature Points

What is a good feature point?

- Very informational
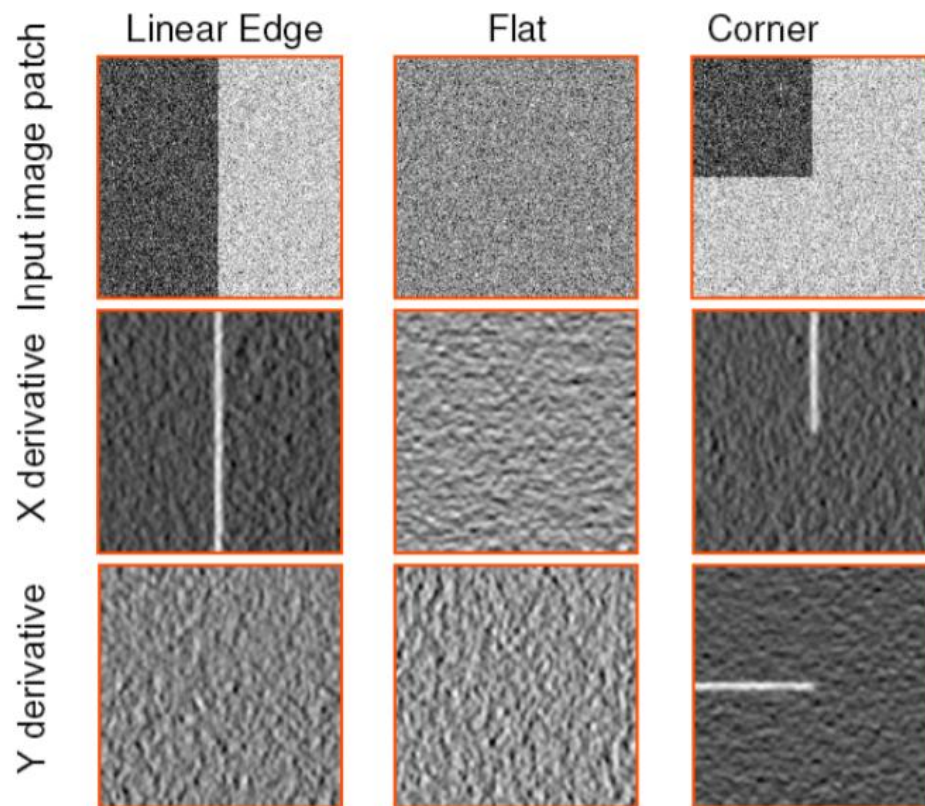
II. Feature Points
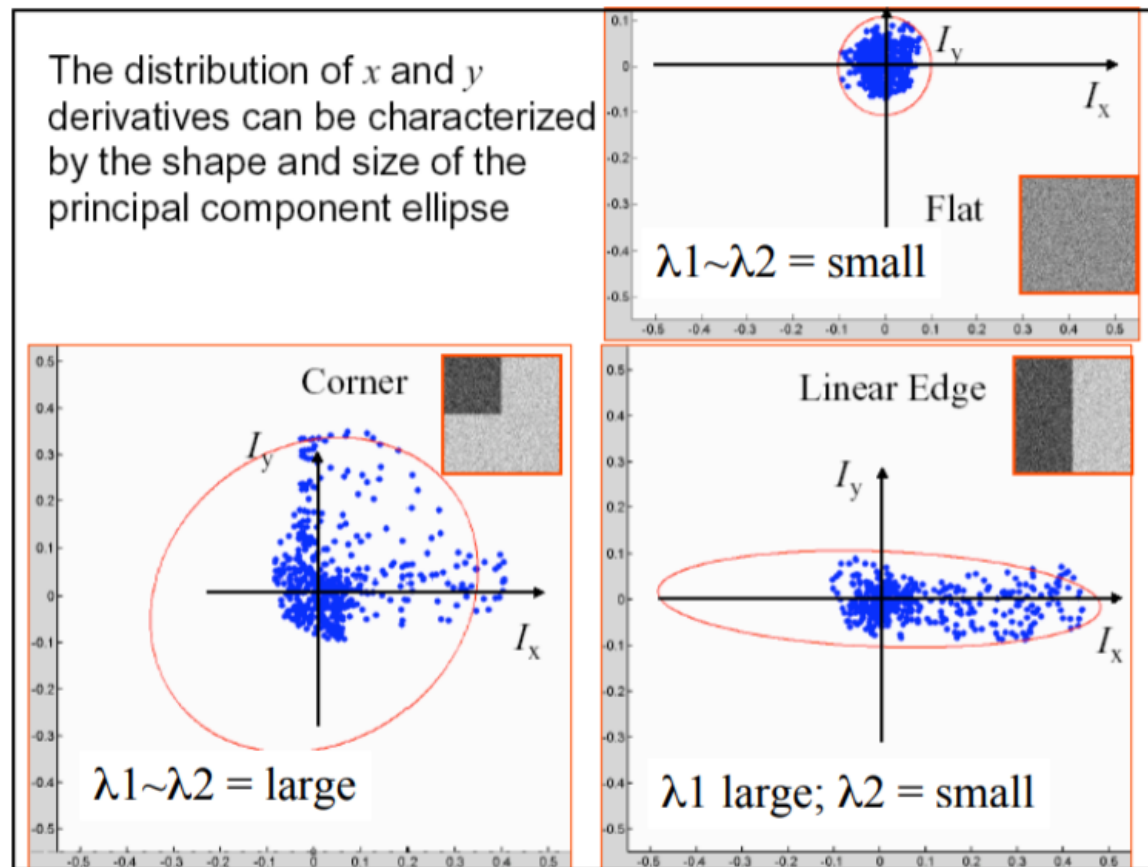
What is a good feature point?

- Very informational (Harris Corner Detector)

II. Feature Points

What is a good feature point?

- Very informational (Harris Corner Detector)

II. Feature Points

What is a good feature point?

- Very informational (Harris Corner Detector)

The distribution of x and y derivatives can be characterized by the shape and size of the principal component ellipse

Flat
$\lambda 1 \sim \lambda 2 =$ small

Corner
$\lambda 1 \sim \lambda 2 =$ large

Linear Edge
$\lambda 1$ large; $\lambda 2 =$ small
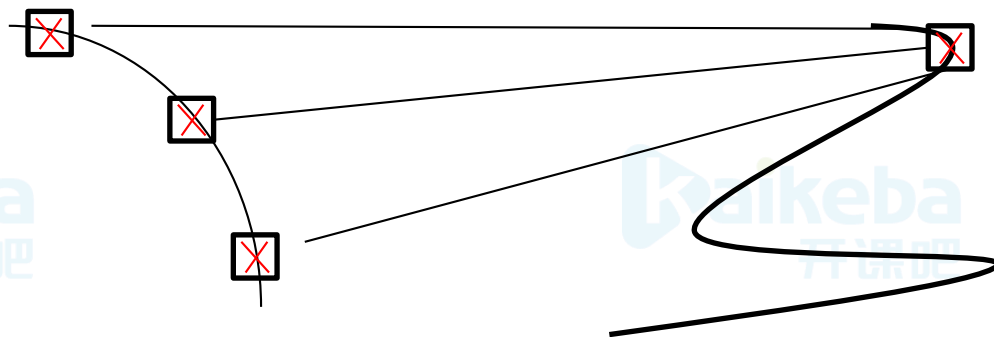
II. Feature Points

What is a good feature point?

- Rotation/Brightness resistance (Harris Corner Detector)

II. Feature Points

What is a good feature point?
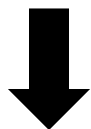
- Scale resistance (Harris Corner Detector)

A + B + C → Good feature point

II. Feature Points

What is the form of a feature point?

Physical in location

Abstract in formation (usually a vector)

$$\Downarrow$$

Feature Descriptor

II. Feature Points

How to get a feature point/descriptor?

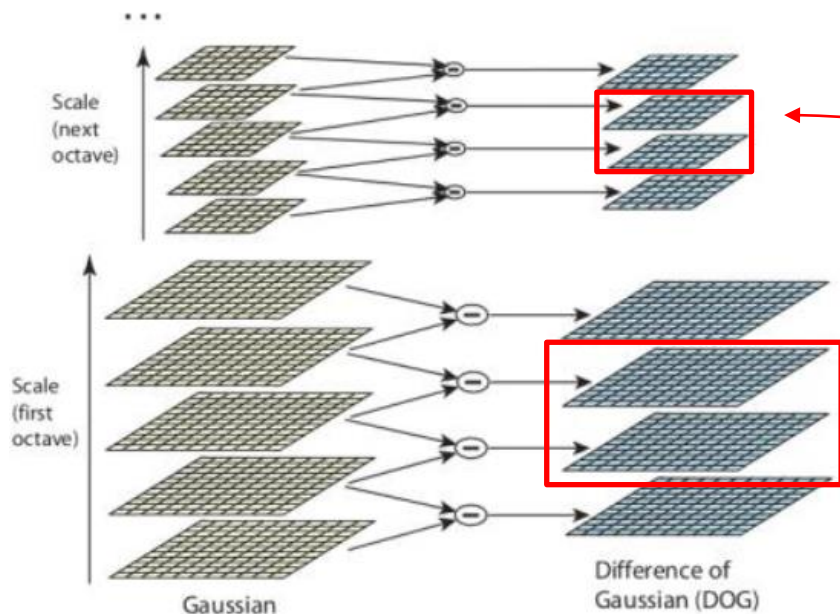e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG
2. Scale-space Extrema Detection
3. Accurate Keypoint Localization
4. Eliminating Edge Responses
5. Orientation Assignment
6. Keypoint Descriptor

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG

$$Octave = [log_2 \min(W,H)] - S$$

$$\sigma_{o,s} = \sigma_0 k^{o+s/S}$$

$$k = 2^{\frac{1}{S}}, S = 2, 3$$

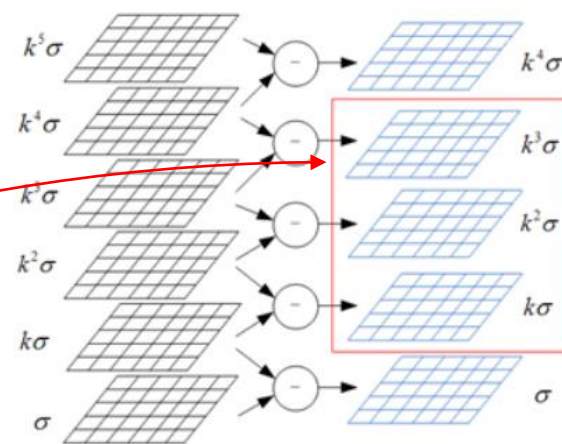$$\sigma_0 = 1.6 \rightarrow original$$

$$= \sqrt{\sigma_0^2 - (2\sigma_n)^2} \rightarrow 1^{st} \text{ layer, } 1^{st} \text{ octave}$$

$$\sigma_n = 0.5$$

$$\# \text{ of scale images} = nOctave * (S + 3)$$

Use bilinear interpolation to get 2xImage as 1st layer in 1st octave

第0组: $\sigma_o \rightarrow 2^{1/3}\sigma_0 \rightarrow 2^{2/3}\sigma_0 \rightarrow 2^{3/3}\sigma_0 \rightarrow 2^{4/3}\sigma_0 \rightarrow 2^{5/3}\sigma_0$

第1组: $2\sigma_o \rightarrow 2*2^{1/3}\sigma_0 \rightarrow 2*2^{2/3}\sigma_0 \rightarrow 2*2^{3/3}\sigma_0 \rightarrow 2*2^{4/3}\sigma_0 \rightarrow 2*2^{5/3}\sigma_0$

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG

II. Feature Points

How to get a feature point/descriptor?
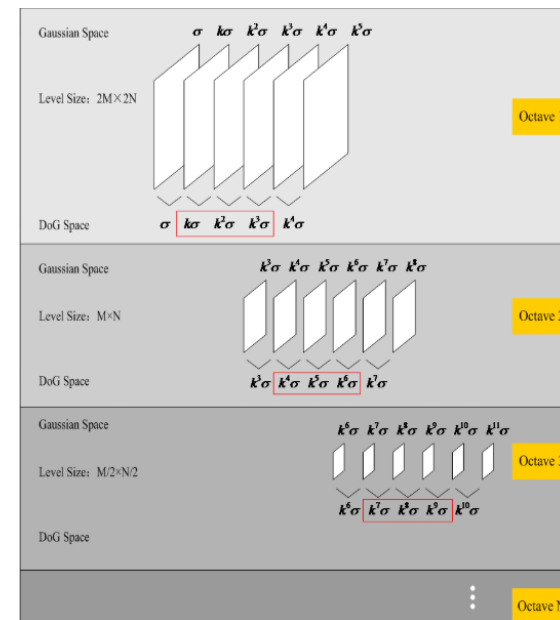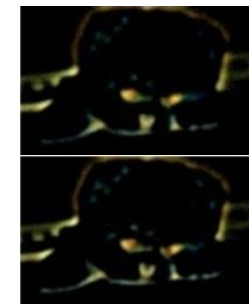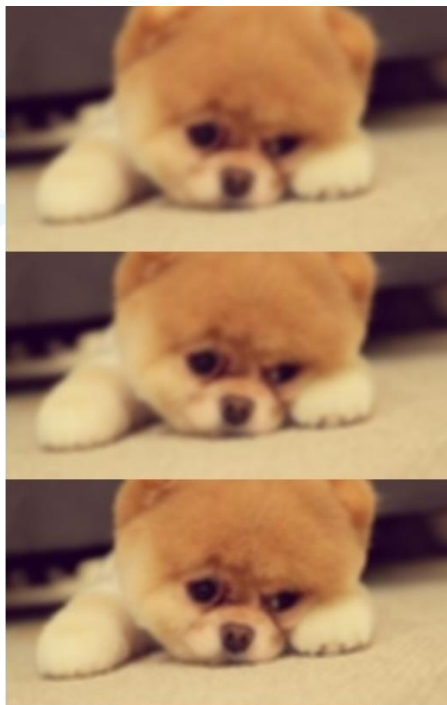
e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG

II. Feature Points

How to get a feature point/descriptor?

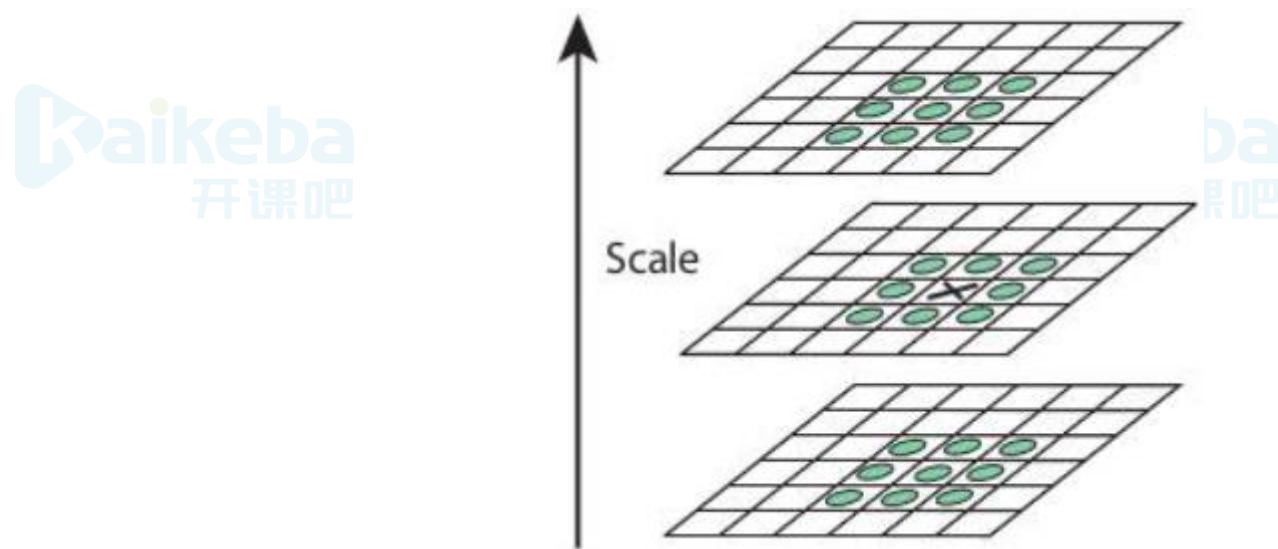e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT $\rightarrow$ Scale-Invariant Feature Transform

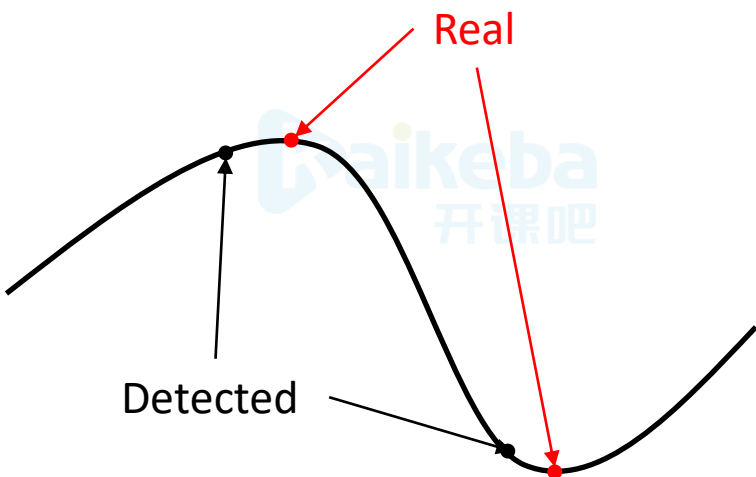2. Scale-space Extrema Detection (min & max)

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

3. Accurate Keypoint Localization

II. Feature Points
How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

4. Eliminating Edge Responses

Reason: DoG is too sensitive to edge, unstable
Method:

$$H = \begin{bmatrix} D_{xx} & D_{xy} \\ D_{xy} & D_{yy} \end{bmatrix}$$

$$Tr(H) = D_{xx} + D_{yy} = \alpha + \beta$$

$$Det(H) = D_{xx} D_{yy} - (D_{xy})^2 = \alpha\beta$$

$$\alpha = r\beta$$

$$ratio = \frac{Tr(H)^2}{Det(H)} = \frac{(r+1)^2}{r}$$

$$let\ ratio < \frac{(r+1)^2}{r}\ when\ r_0 = 10$$

Theory: Curvature & Hessian Matrix

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

5. Orientation Assignment

$r = 3*1.5\sigma$

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2}$$

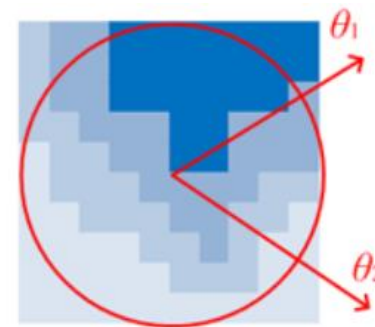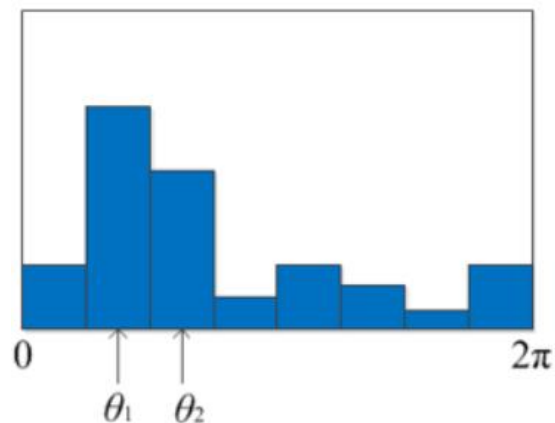$$\theta(x,y) = \arctan(\frac{L(x,y+1) - L(x,y-1)}{L(x+1,y) - L(x-1,y)})$$

10bin, 0-360°
(we can also use interpolation here)

θ_2 at least 80% of θ_1,
main direction

We get (x, y, σ, θ) for each feature point

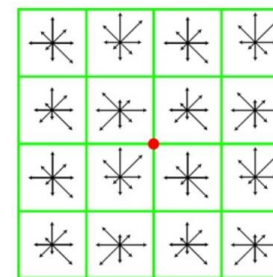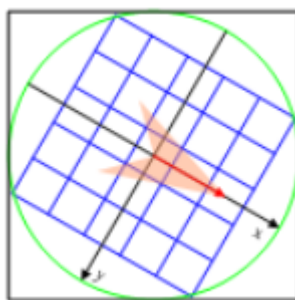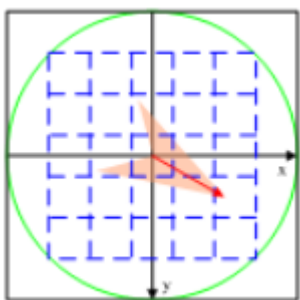# II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

6. Keypoint Descriptor

For each keypoint, we have a 4x4x8=128 dimension vector as its descriptor

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

6. Keypoint Descriptor

Features:
a. Almost the most accurate one
b. Scale, brightness, rotation friendly
c. Computing consuming and slow

II. Feature Points

How many types of feature points?

Besides SIFT, we have:

FAST

SURF

BRIEF

HoG

Orb

…

Reading assignment

⟵
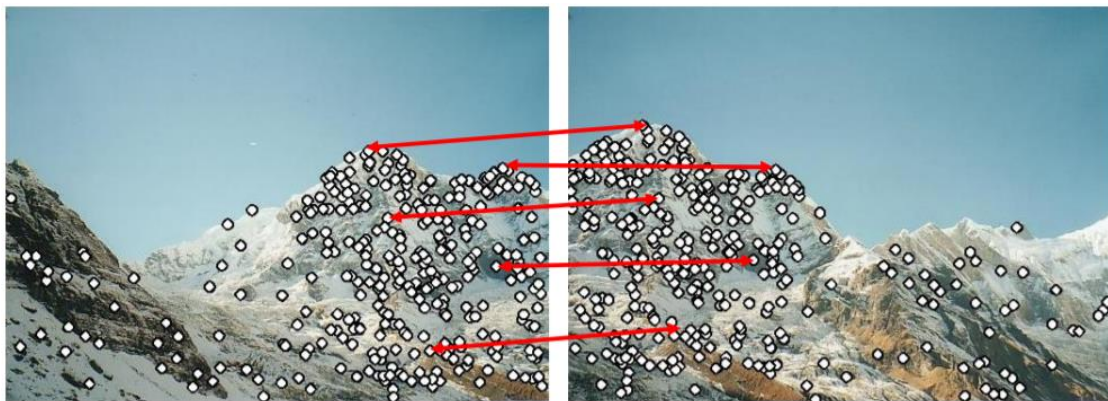
FAST: faster version of SIFT
HoG: detection
Orb: SLAM guys' friend

II. Feature Points
Any applications?

- Image Stitching

Pipeline:
1. Find feature points in each image
2. Use RANSAC to find keypoint matches
3. Use homography matrix to get transferring info
4. Merge two images

This is an additional coding assignment.

II. Feature Points
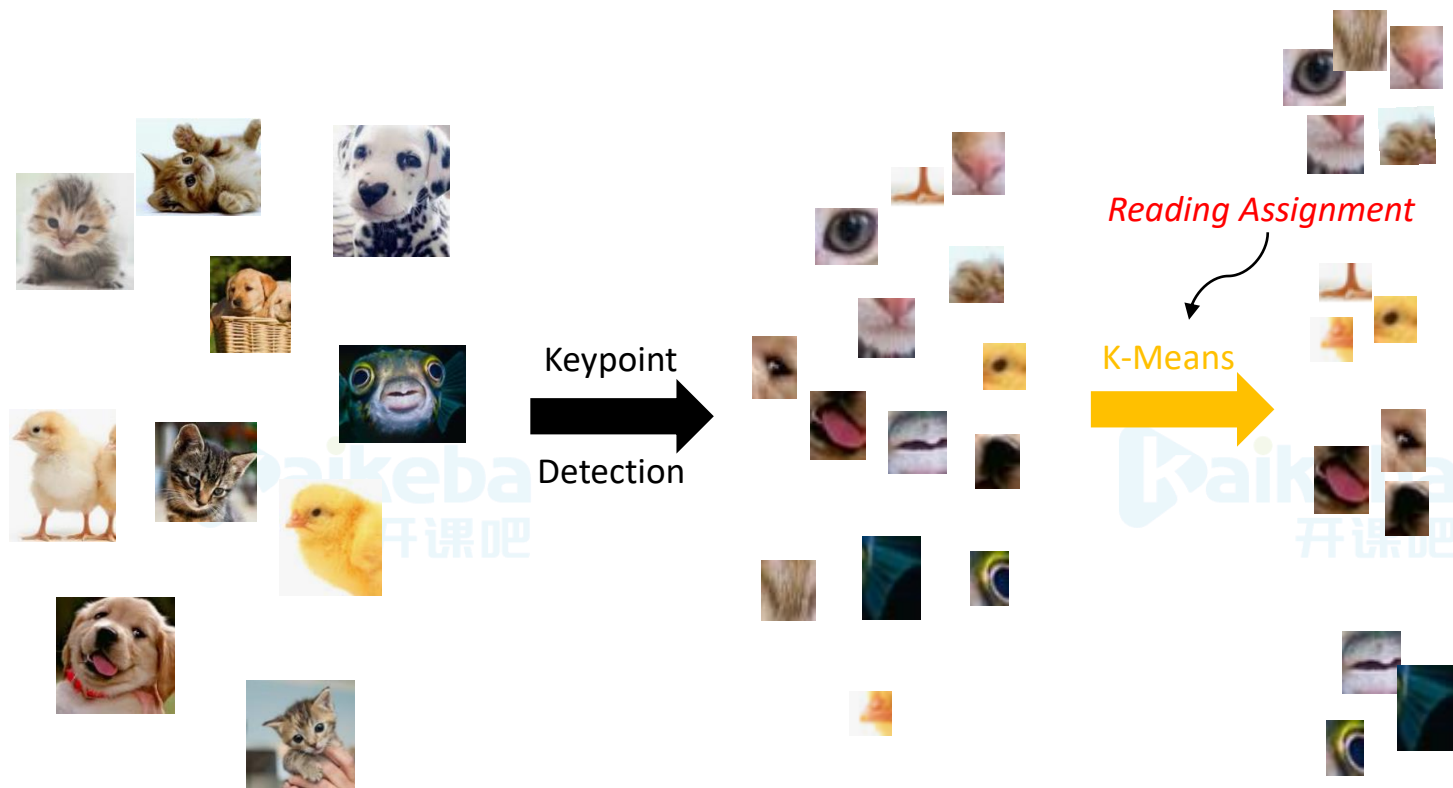
Any applications?

- Classification

Original image → Get features → Classification → Retrieval…

III. Classical CV Procedure
(High Level)

III. Classical CV Procedure

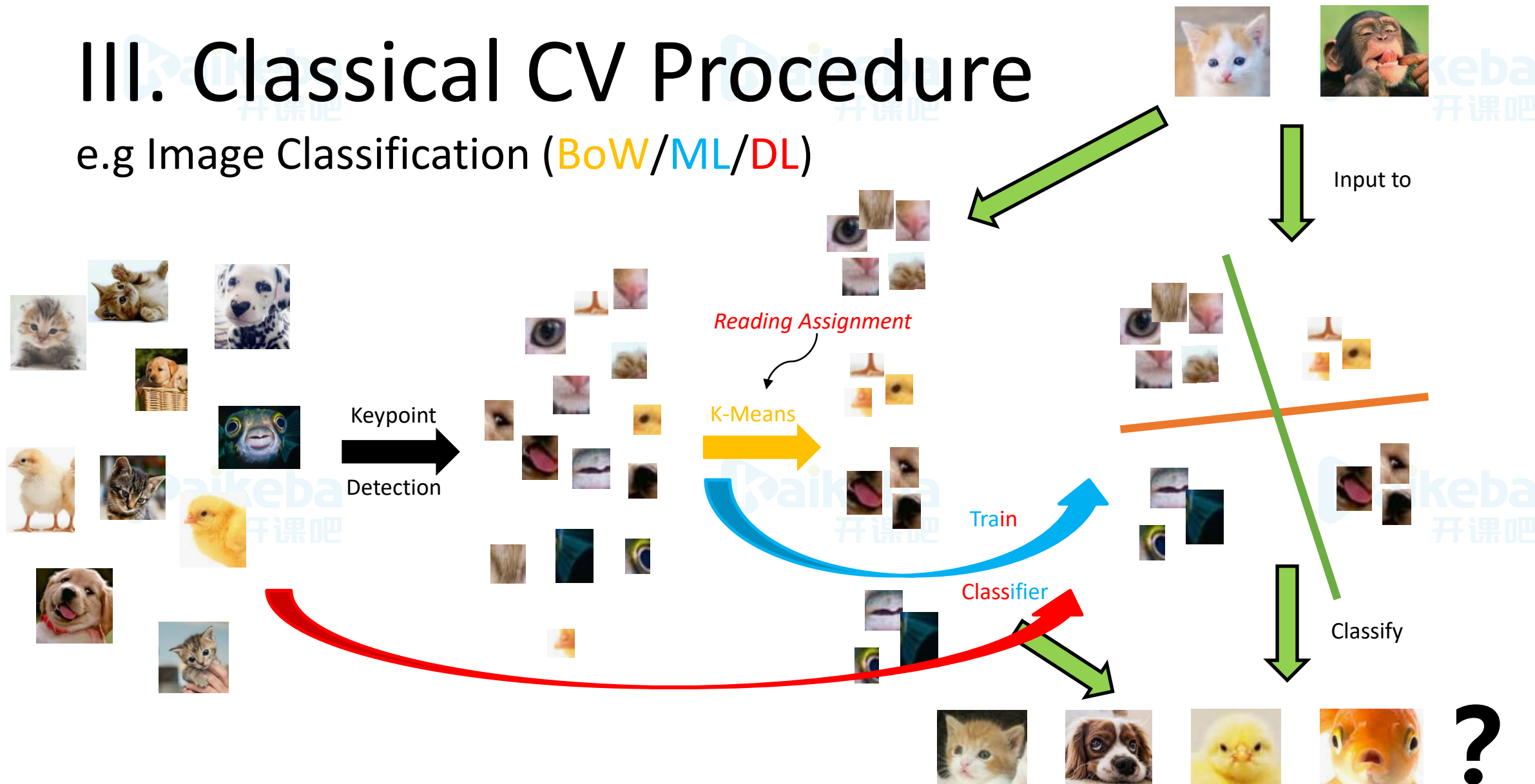e.g Image Classification (Bag of Words/BoW)

Keypoint

Detection

Reading Assignment

K-Means

III. Classical CV Procedure

e.g Image Classification (ML)

Keypoint Detection

Train Classifier

III. Classical CV Procedure

e.g Image Classification (BoW/ML/DL)

Keypoint Detection

Reading Assignment

K-Means

Train

Classifier

Input to

Classify

?

III. Classical CV Procedure

Advanced : image retrieval
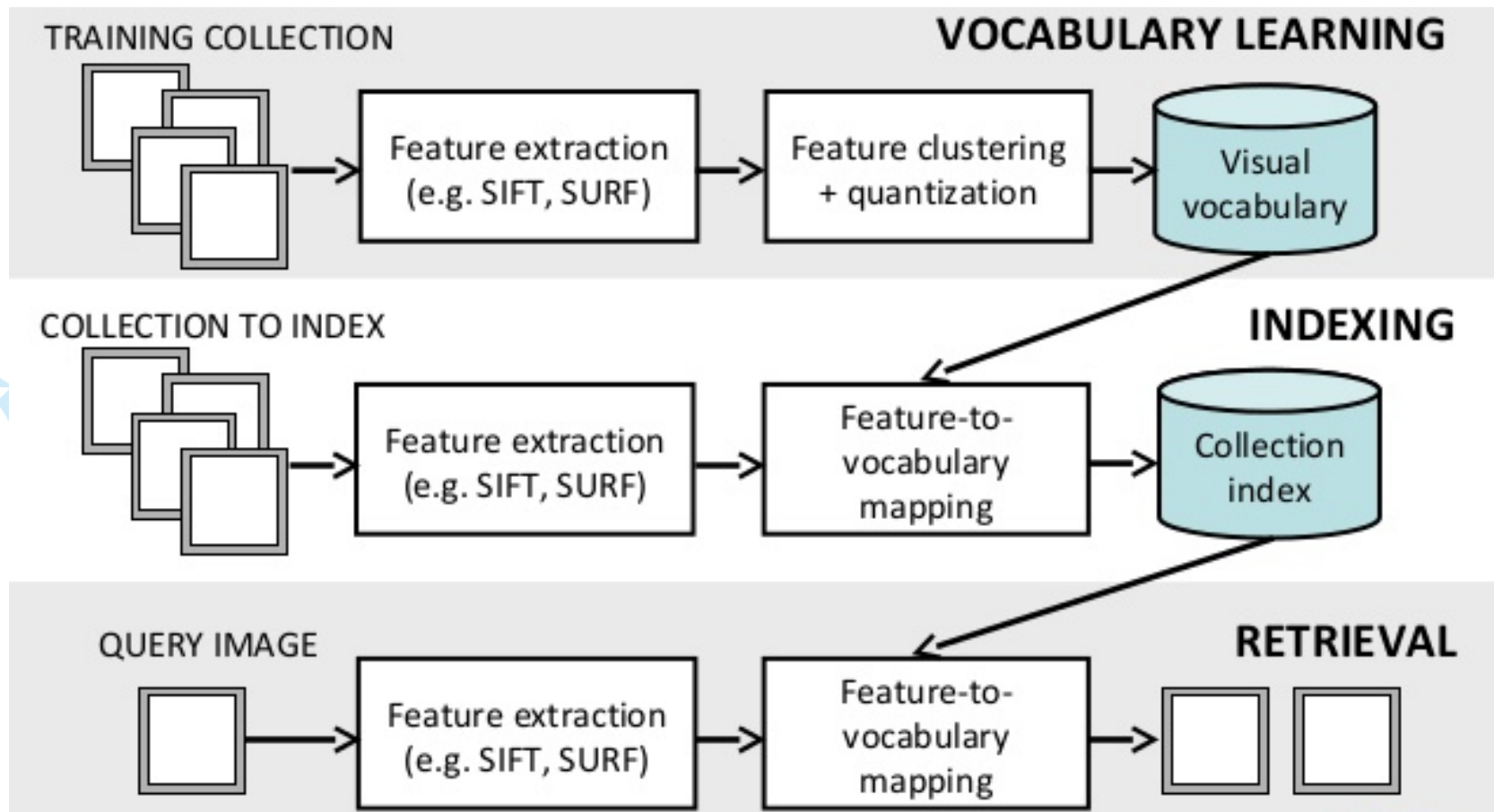
Assignments:

1. Code a function to do median blur operations by your self.
   Can it be completed in a shorter time complexity?

2. Read RANSAC algorithm and write a pseudo code about it.