CNN for CV

AI for CV Group
2019

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

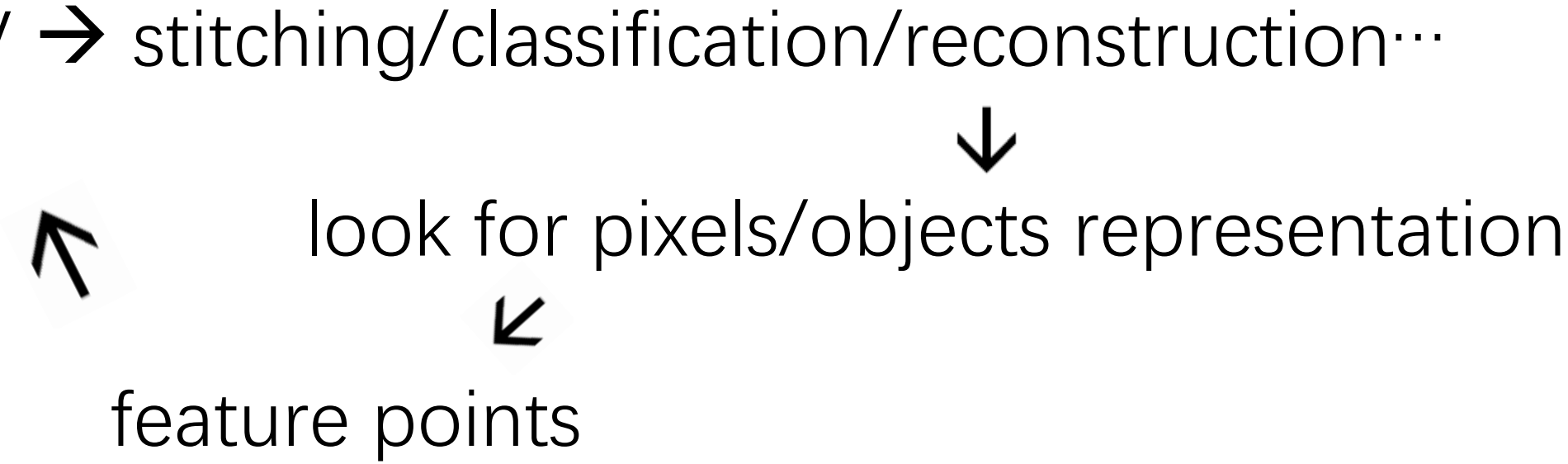
(Mid Level)

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

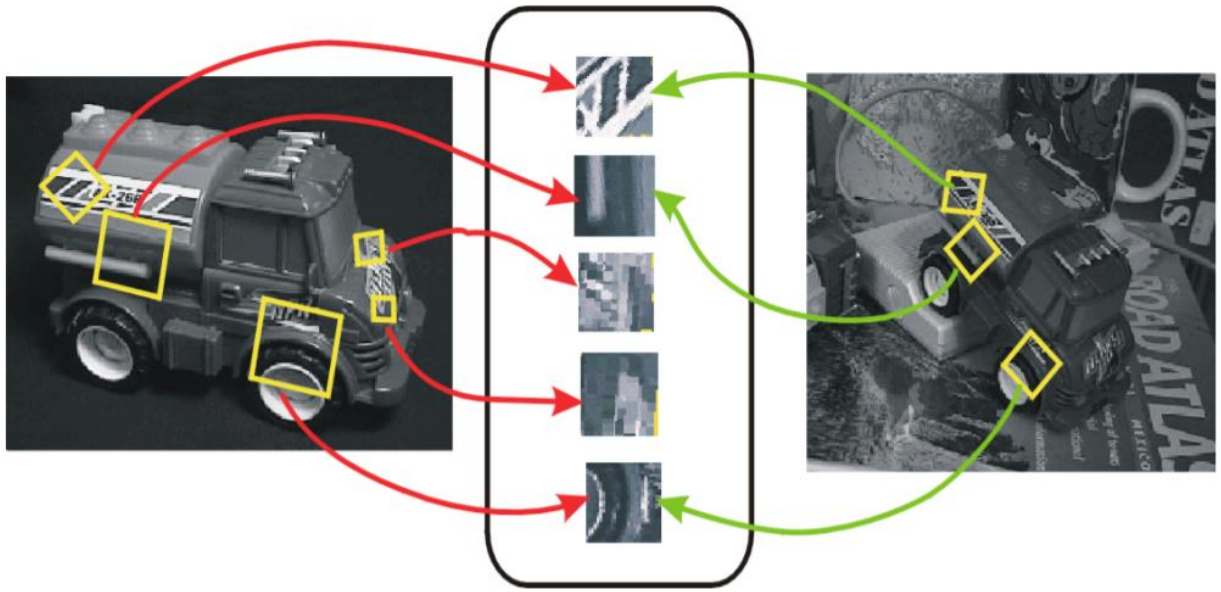
Why we need feature points?

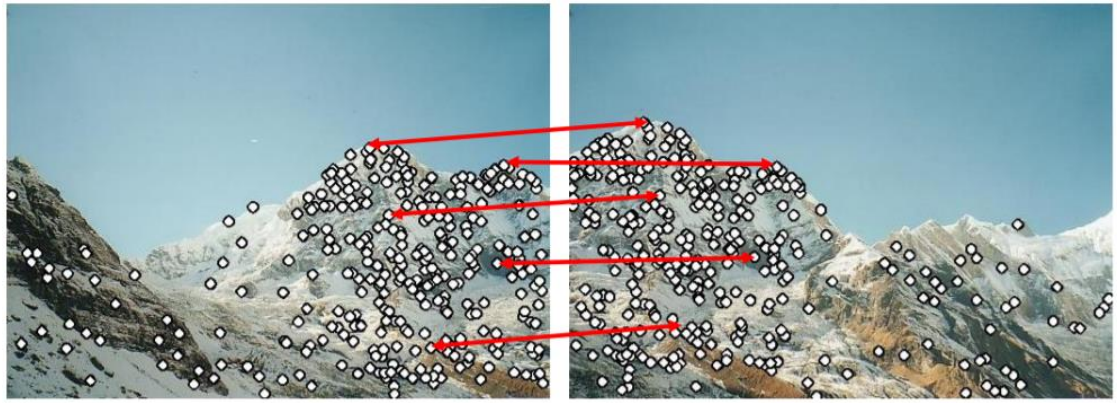


II. Feature Points

What is a feature point?

Represents of objects/pixels





II. Feature Points

What is a good feature point?

- Very informational

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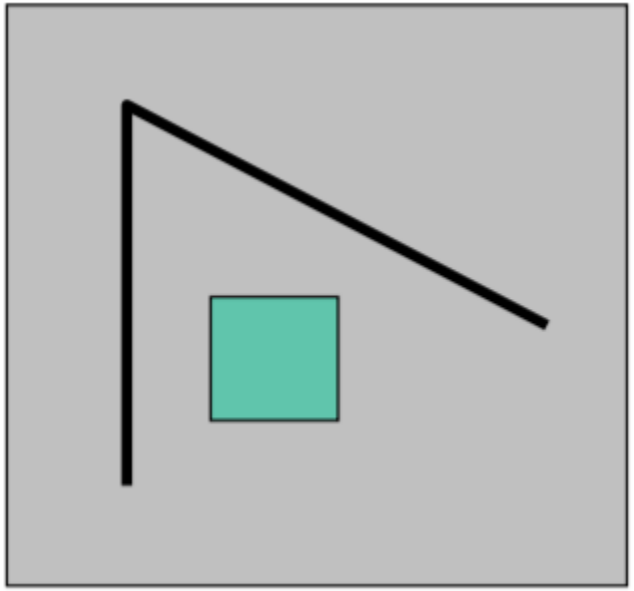

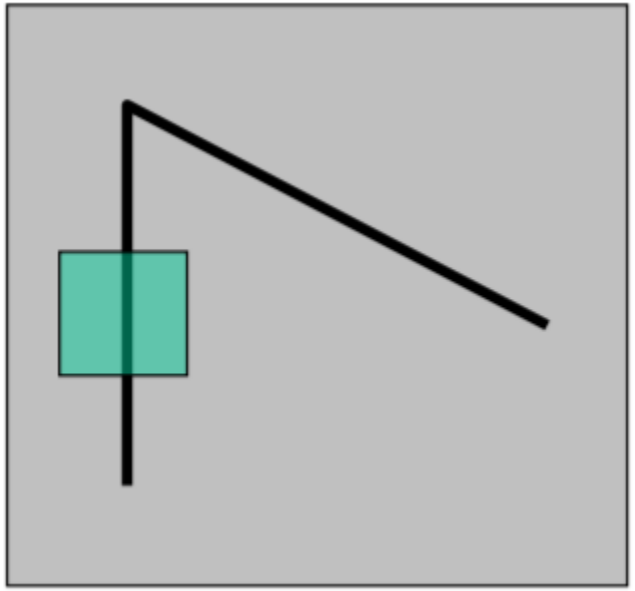

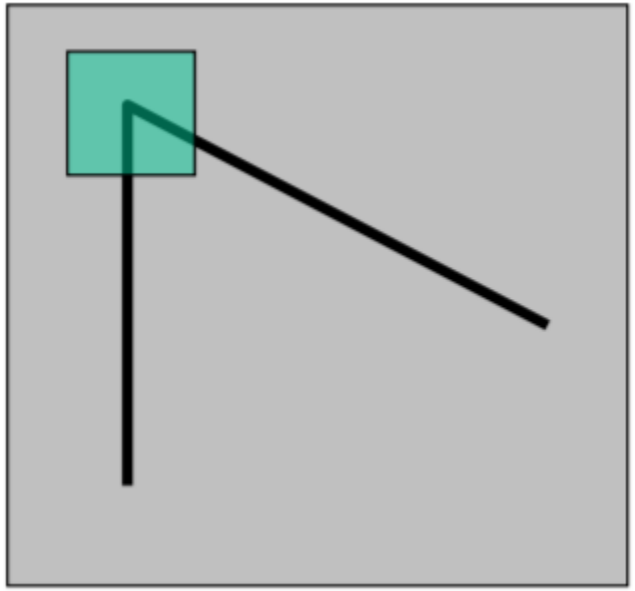

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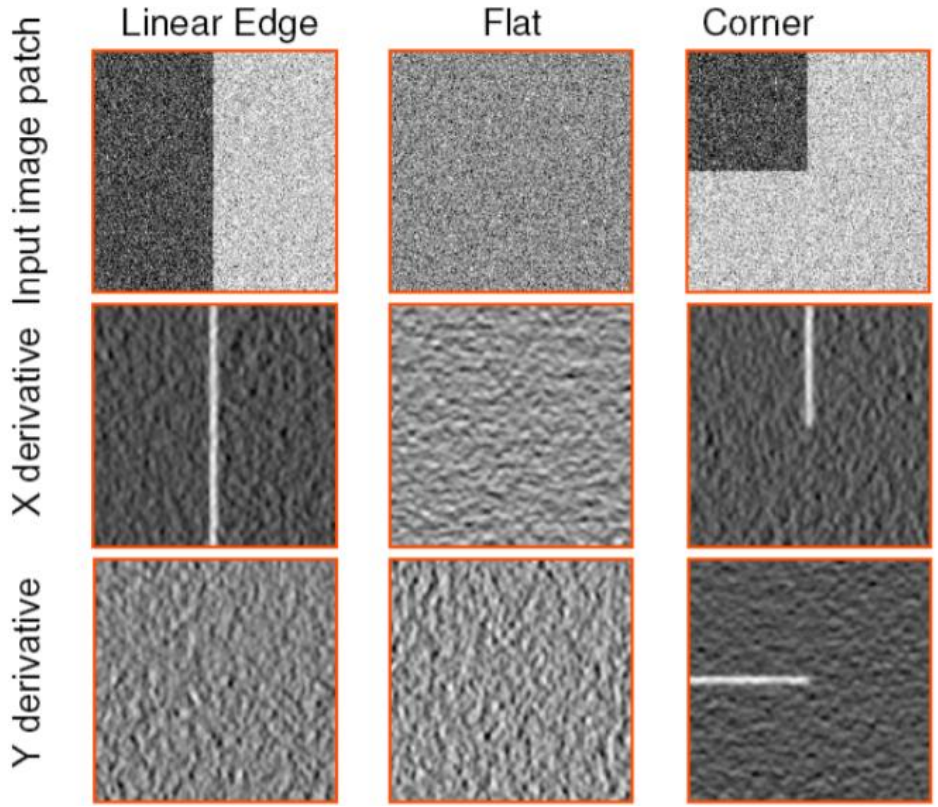

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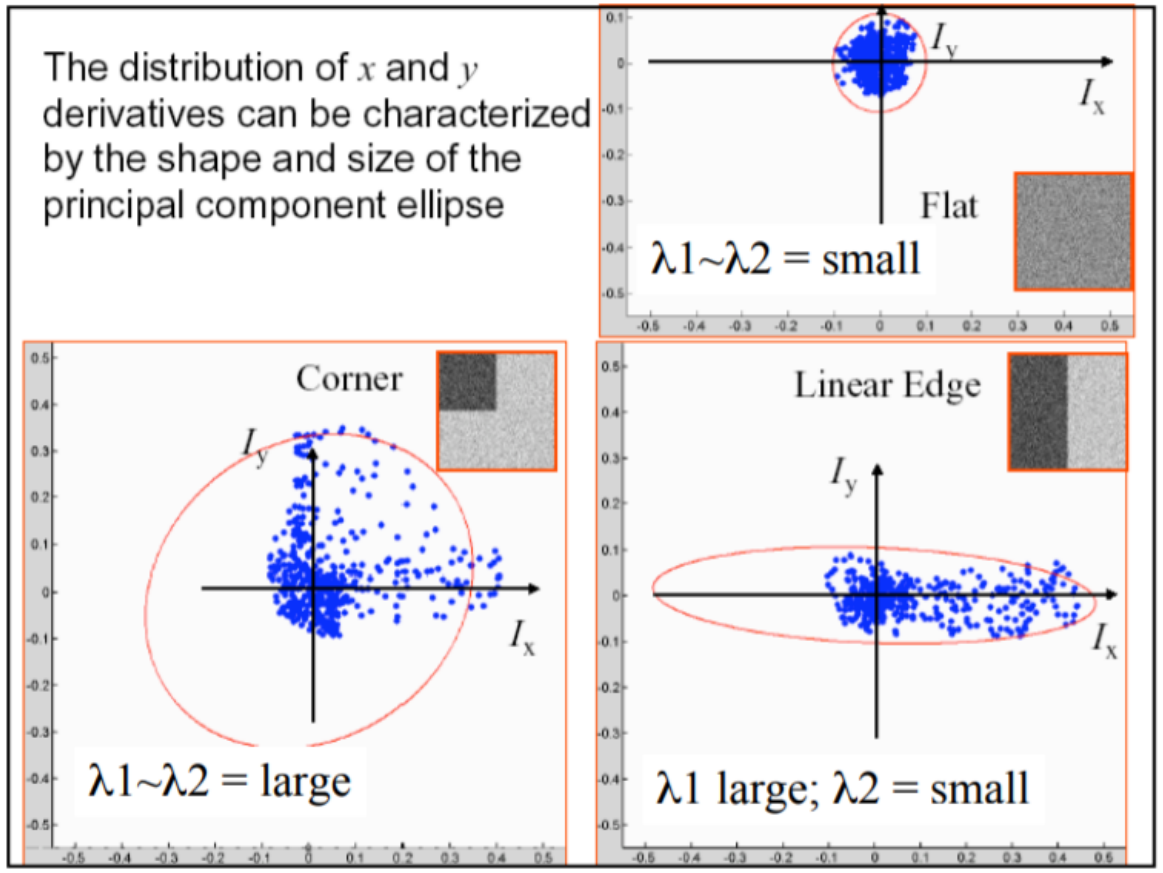


II. Feature Points

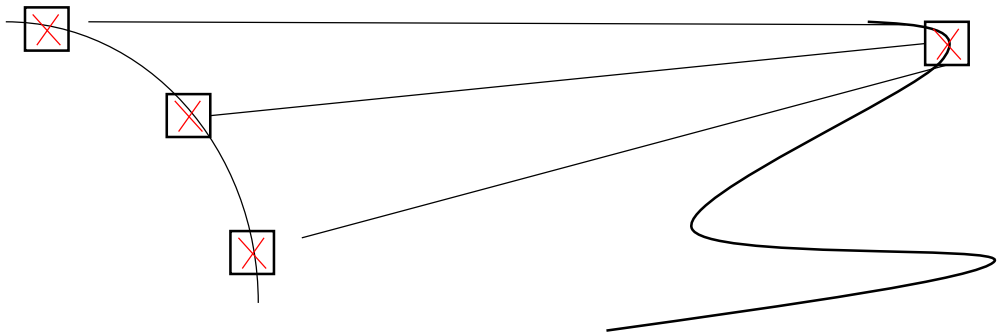
What is a good feature point?

- 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)

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

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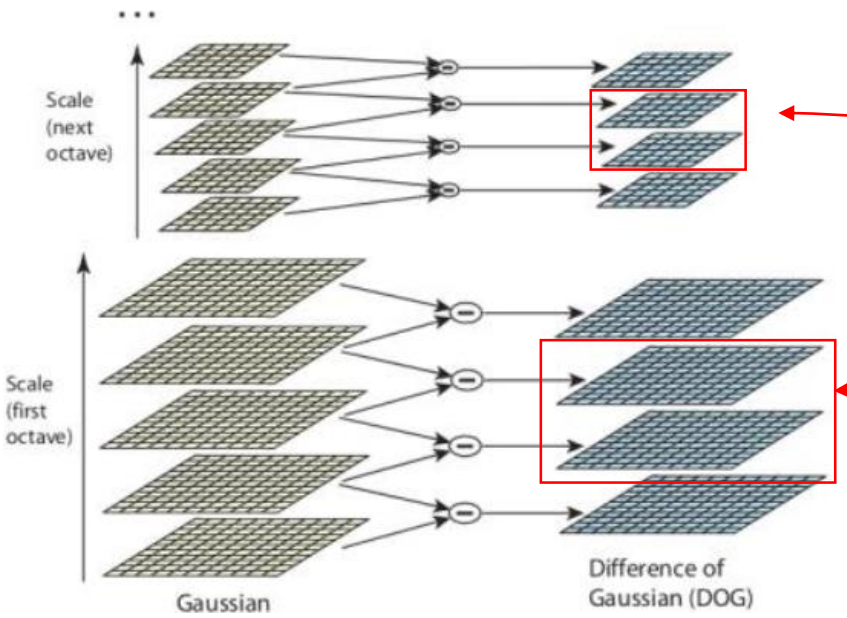
e.g SIFT → Scale-Invariant Feature Transform

1. Generate Scale-space: DoG



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

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

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

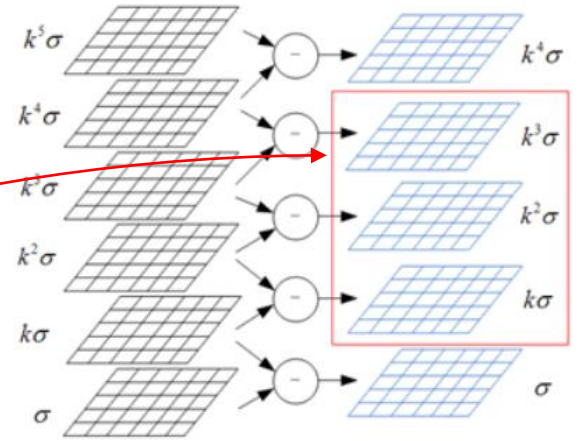
$\sigma_0 = 1.6$ → original

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

$\sigma_n = 0.5$

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

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



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

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

II. Feature Points

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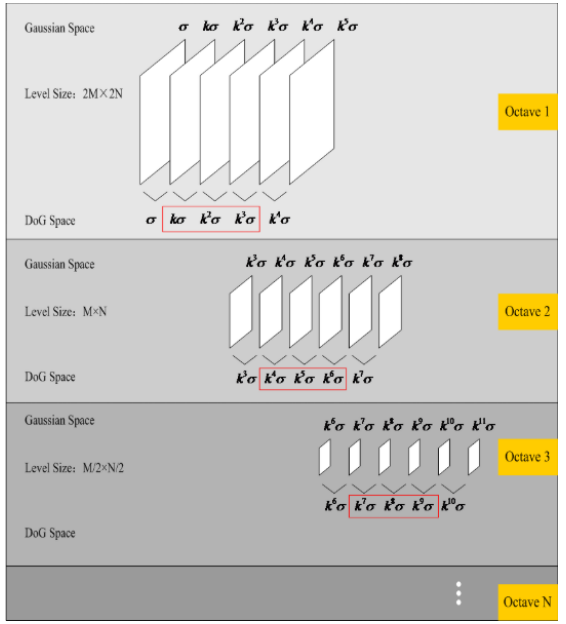
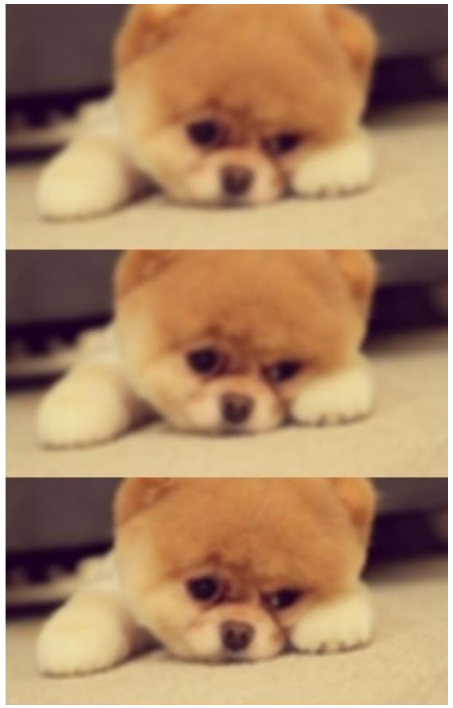
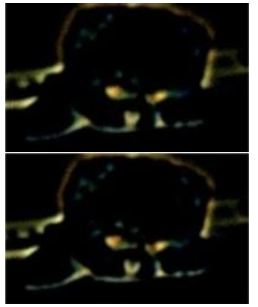




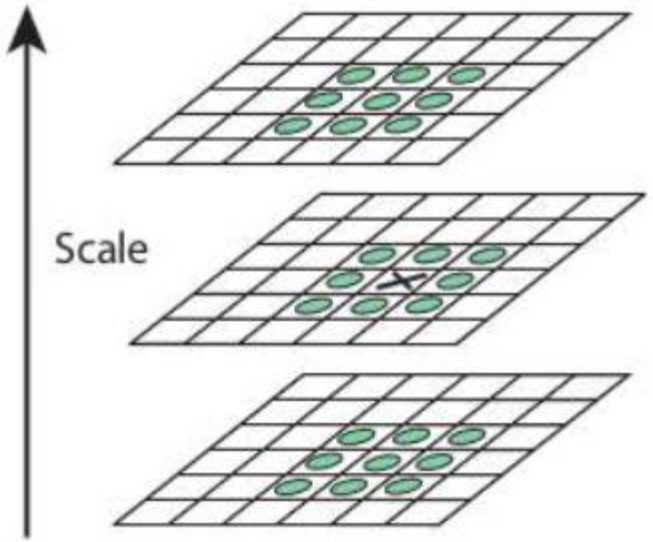


II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

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

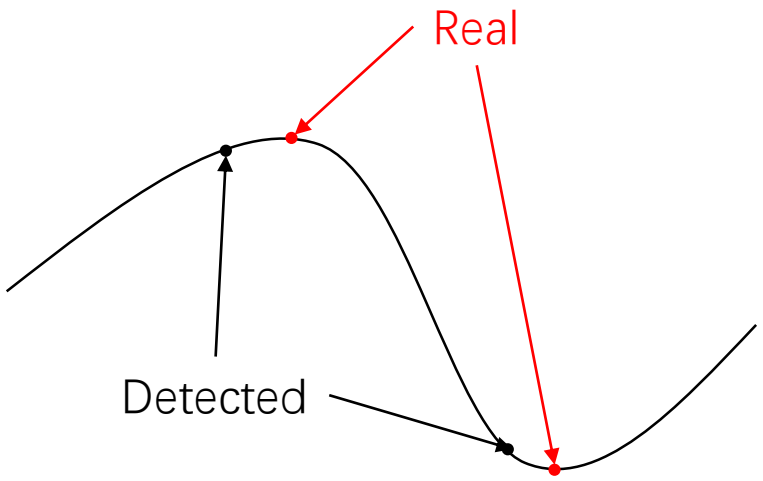


II. Feature Points

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

Theory: Curvature & Hessian Matrix

Method:

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

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

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

$$\alpha = r\beta$$

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

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

II. Feature Points

How to get a feature point/descriptor?

e.g SIFT → Scale-Invariant Feature Transform

5. Orientation Assignment

r =3*1.5σ

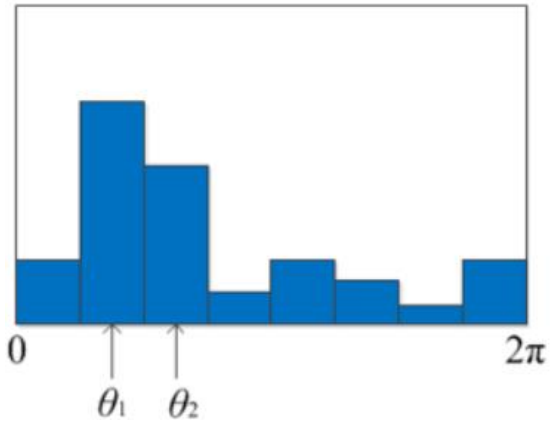
$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2}$$

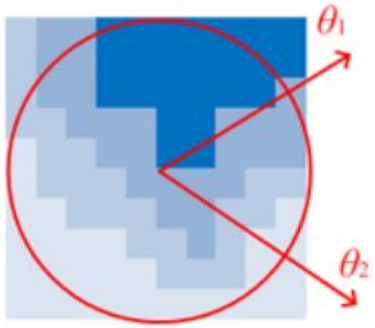
$$\theta(x,y) = \arctan\left(\frac{L(x,y+1) - L(x,y-1)}{L(x+1,y) - L(x-1,y)}\right)$$

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



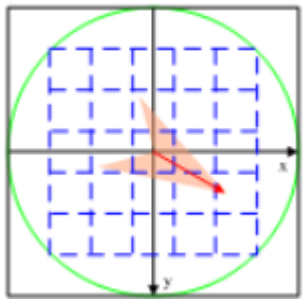


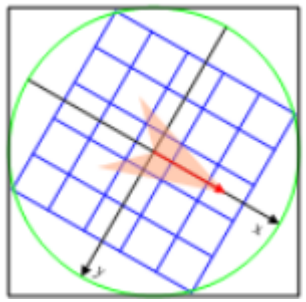
II. Feature Points

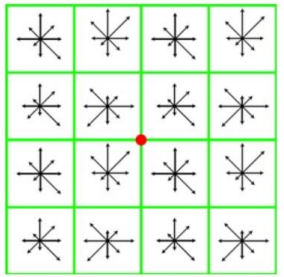
How to get a feature point/descriptor?

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
…

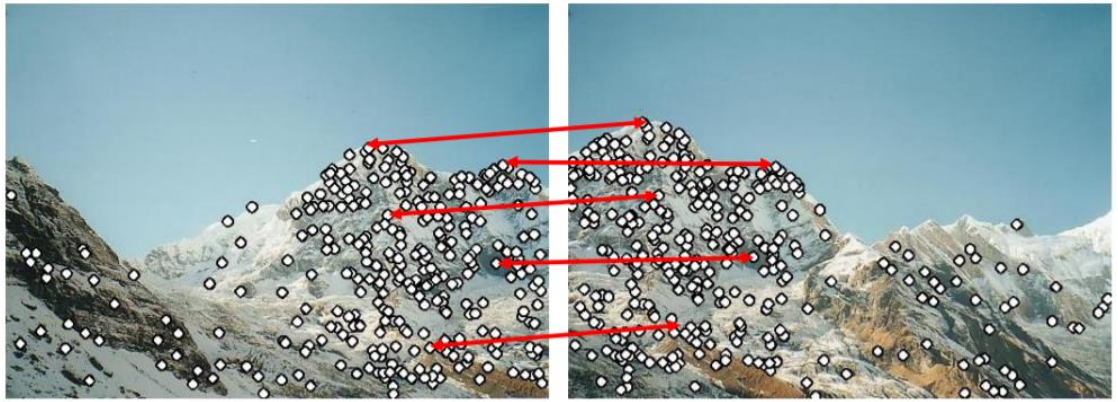
Reading assignment

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

II. Feature Points

Any applications?

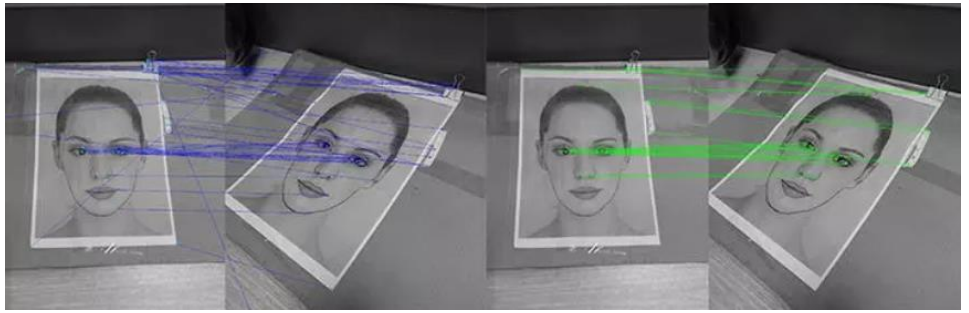
- Image Stitching



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

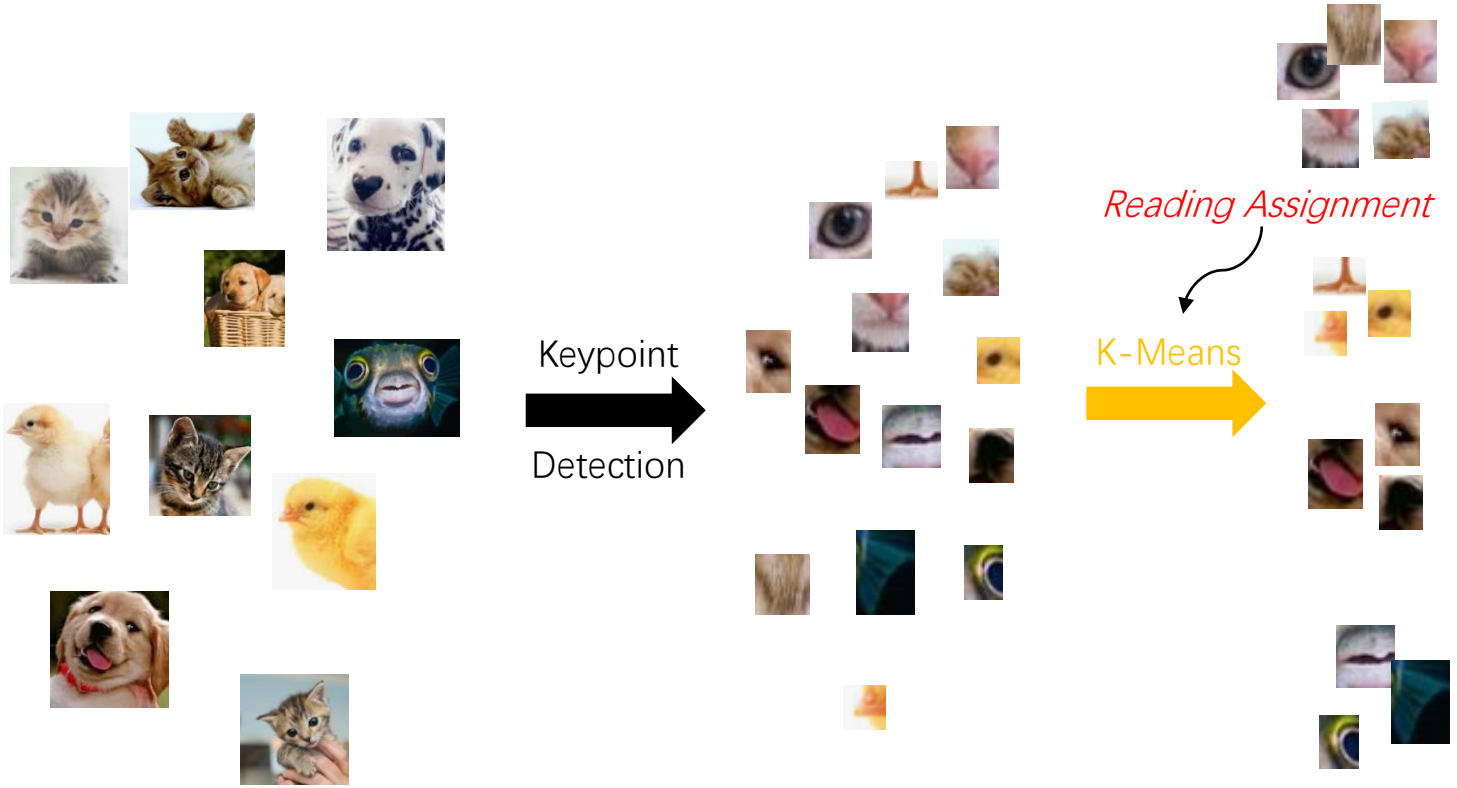
Original image → Get features → Classification

III. Classical CV Procedure

(High Level)

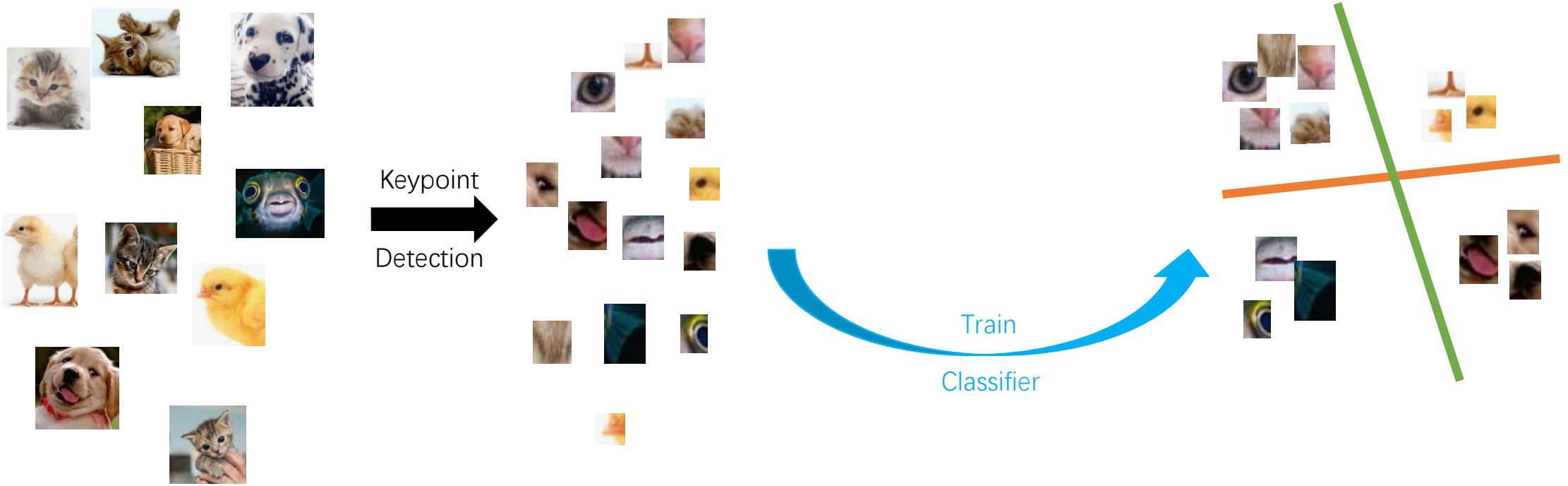
III. Classical CV Procedure

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



III. Classical CV Procedure

e.g Image Classification (ML)



III. Classical CV Procedure

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