计算机视觉
Computer Vision

-- Matching 2

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图像匹配

特征检测 → 特征匹配 → 运动估计

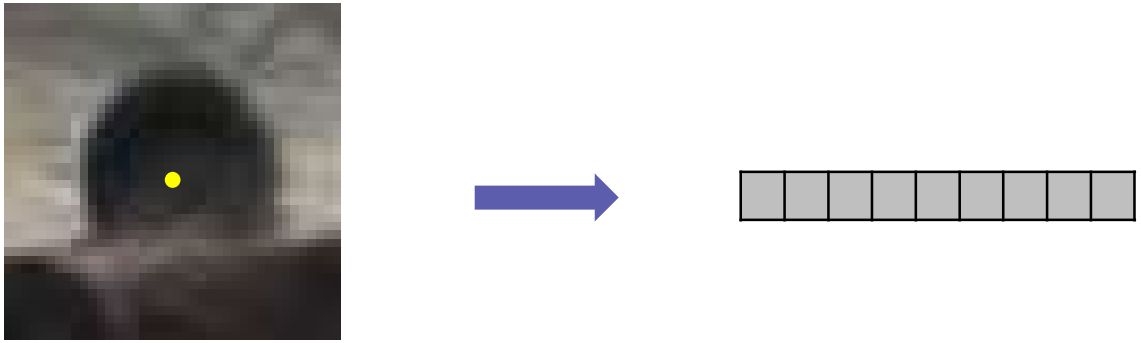
特征检测


ALGEBRA
OPTICS
LONGMAN
DICTIONARY OF
CONTEMPORARY
ENGLISH

特征匹配

特征=>特征描述

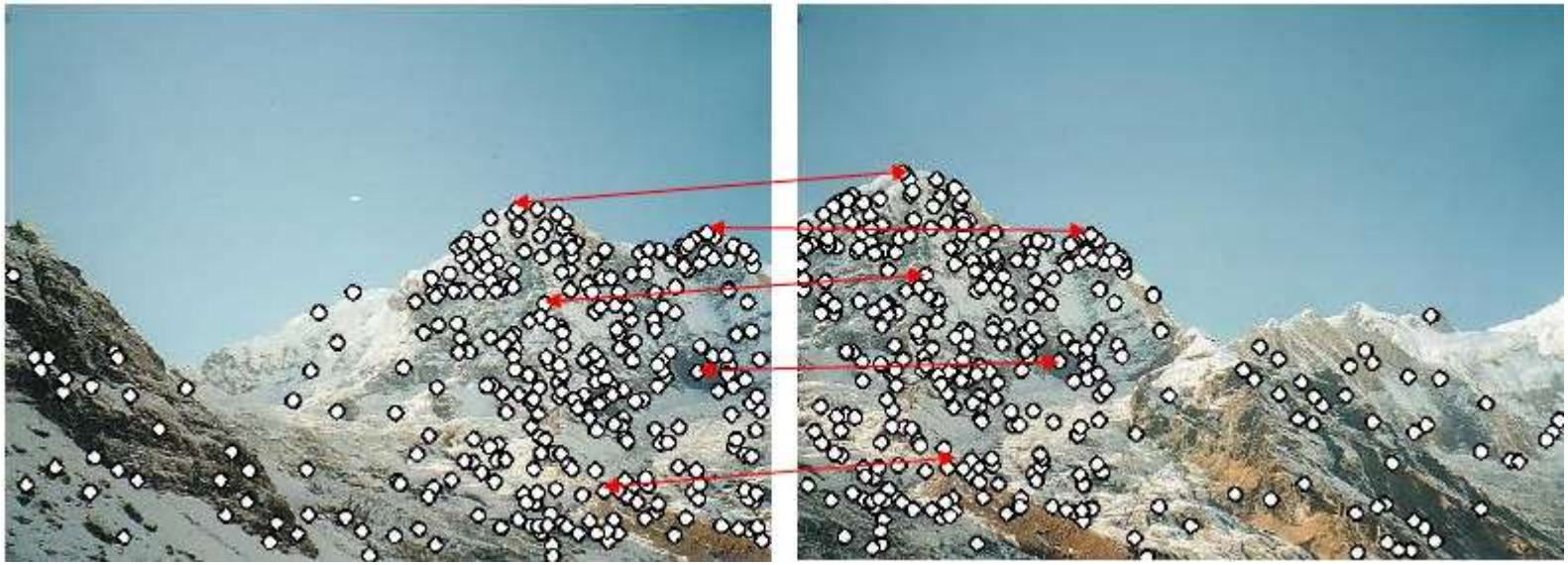
- 将特征所在的局部图像块转换为一个描述特征的向量



特征（图像块）　　特征描述（向量）

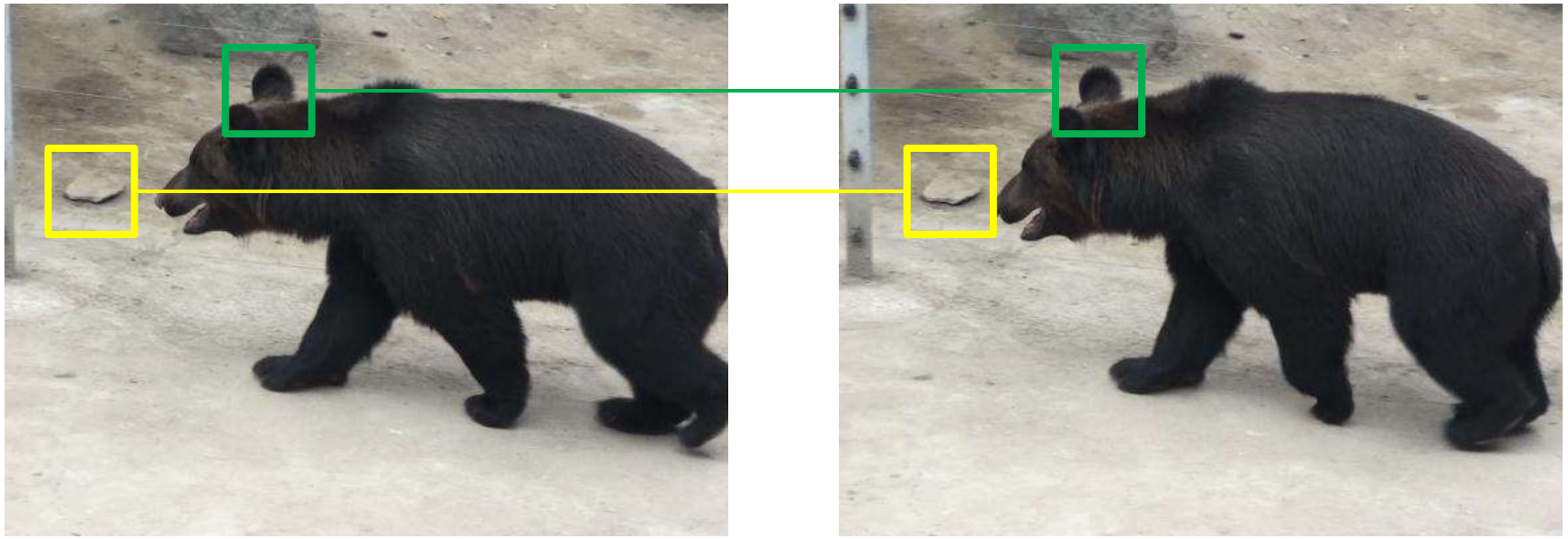
对特征描述的要求

- 不变性（**Invariant)**
- 区分性（**Distinctive, Discriminative**）



先忽略几何变换

- 没有明显的旋转、缩放等，只有小的对齐误差
- 需要考虑颜色的变化（光照、噪音、模糊）



光流 (Optical Flow)

S

T

$$q = M(p)$$

SSD (Sum of Square Difference)

$$\mathrm{ssd}(P,Q) = \sum_{(x,y)} | P(x,y) - Q(x,y) |^2$$

P Q

SAD (Sum of Absolute Difference)

$$\mathrm{sad}(P,Q) = \sum_{(x,y)} | P(x,y) - Q(x,y) |$$

P Q

NCC (Normalized Cross Correlation)

$$\mathrm{cc}(P,Q) = \langle P, Q \rangle$$

$$\mathrm{ncc}(P,Q) = \left\langle \frac{P}{\| P \|}, \frac{Q}{\| Q \|} \right\rangle$$

$$\mathrm{zncc}(P,Q) = \left\langle \frac{P - \bar{P}}{\| P - \bar{P} \|}, \frac{Q - \bar{Q}}{\| Q - \bar{Q} \|} \right\rangle$$

Census Transform

- 对图像块的二值编码
  - **Non-parametric local transforms for computing visual correspondence, ECCV'1994.**

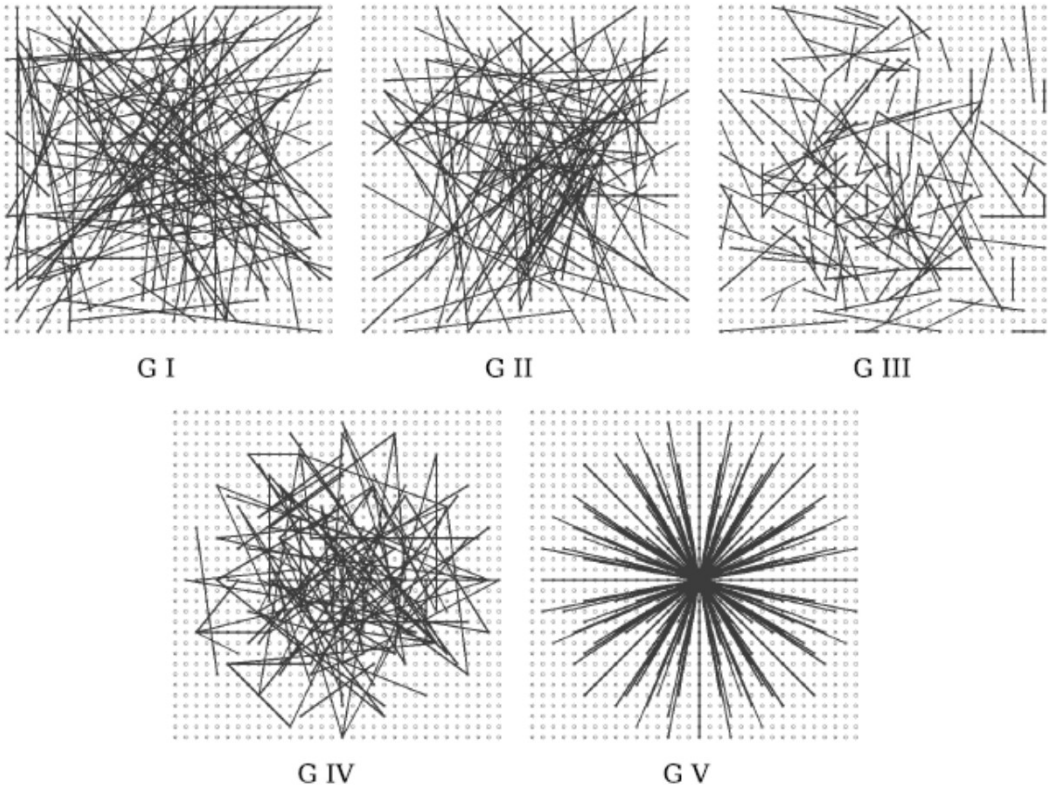
120	127	97
99	100	108
87	23	189

1	1	0
0		1
0	0	1

$$\mathrm{ct}(P,Q) = CT(P)\ \mathrm{XOR}\ CT(Q)$$

BRIEF

- **BRIEF: Binary Robust Independent Elementary Features, ECCV'2010.**



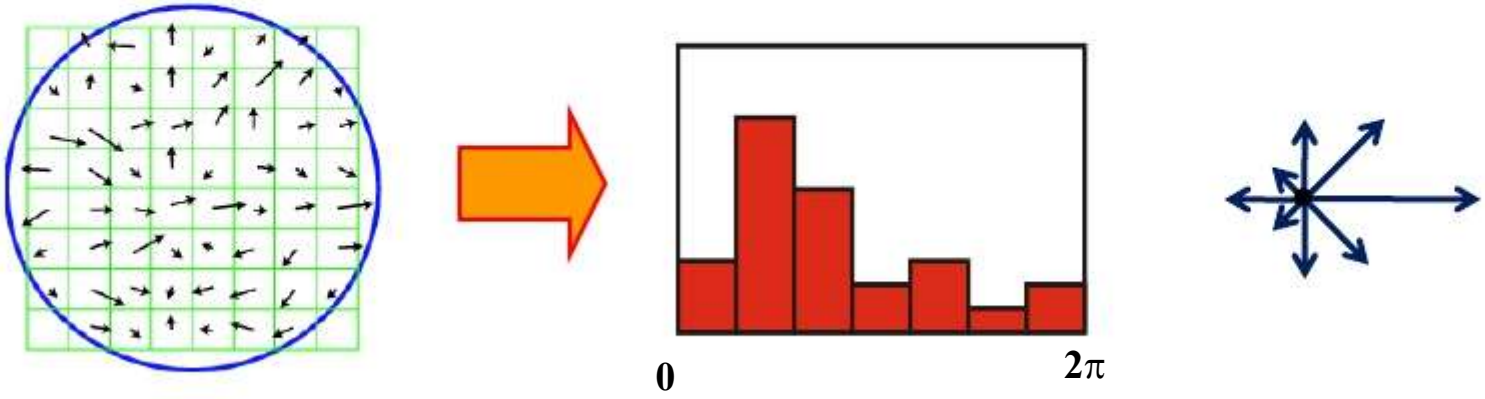
讨论

- 对光照颜色变化（加性、线性、仿射、噪音）的稳定性
- 对微小对齐误差的稳定性

考虑对齐误差

- **Disadvantage of patches as descriptors:**
  - **Small shifts can affect matching score a lot**

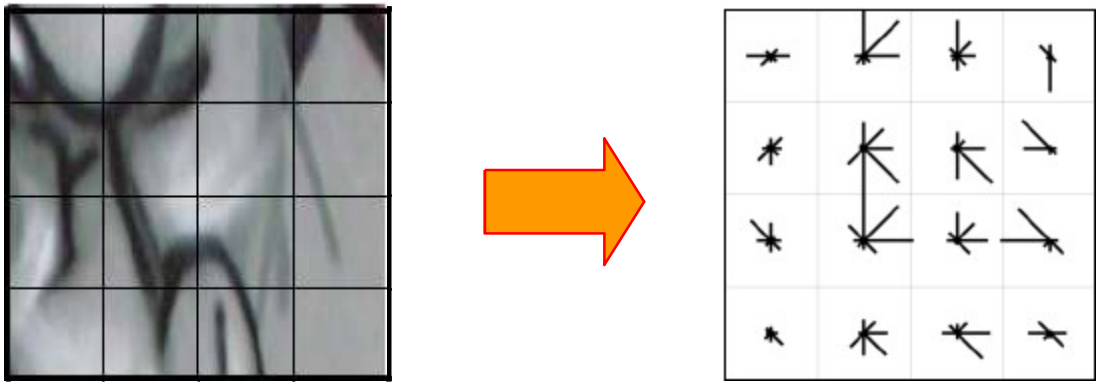
- **Solution: histograms**



Slide credit: Svetlana Lazebnik

Feature Descriptors: SIFT

- Scale Invariant Feature Transform
- Descriptor computation:
  - Divide patch into 4x4 sub-patches: 16 cells
  - Compute histogram of gradient orientations (8 reference angles) for all pixels inside each sub-patch
  - Resulting descriptor: 4x4x8 = 128 dimensions

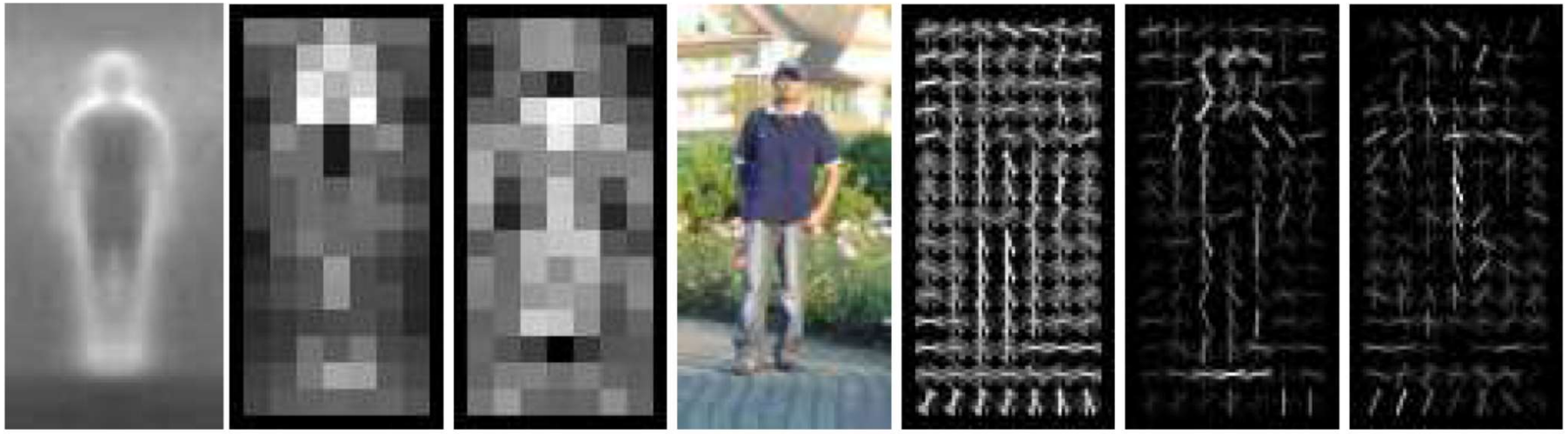


David G. Lowe. "Distinctive image features from scale-invariant keypoints." *IJCV* 60 (2), pp. 91-110, 2004.

Slide credit: Svetlana Lazebnik

其它Histogram-based…

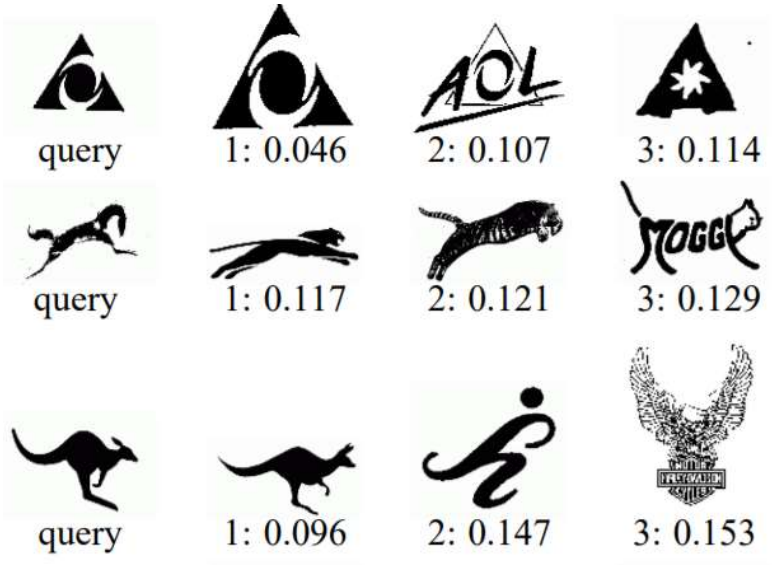
- **HOG**
  - **Histograms of Oriented Gradients for Human Detection, CVPR'05**

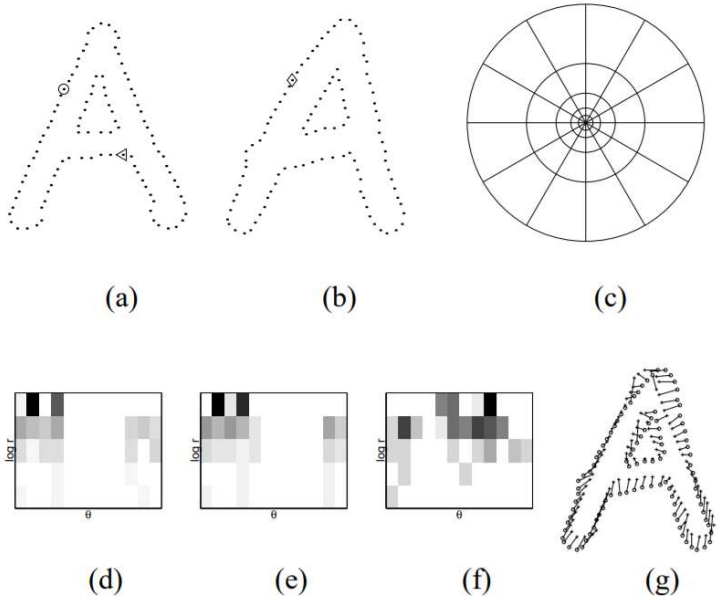


(a) (b) (c) (d) (e) (f) (g)

其它Histogram-based…

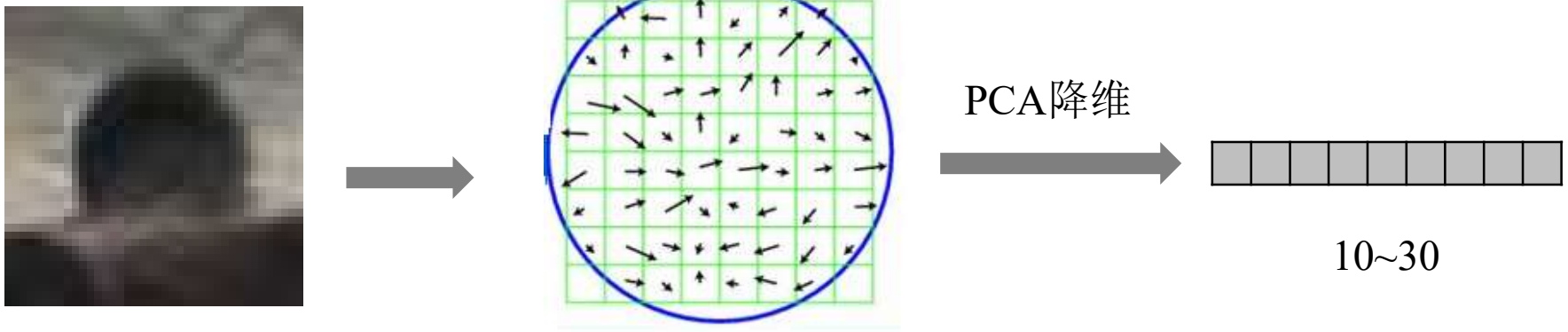
- **Shape Context**
  - **Matching Shapes, ICCV'2001**

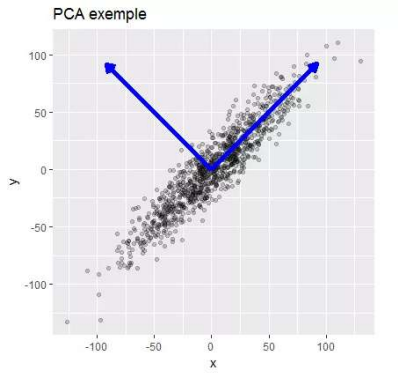




PCA-SIFT

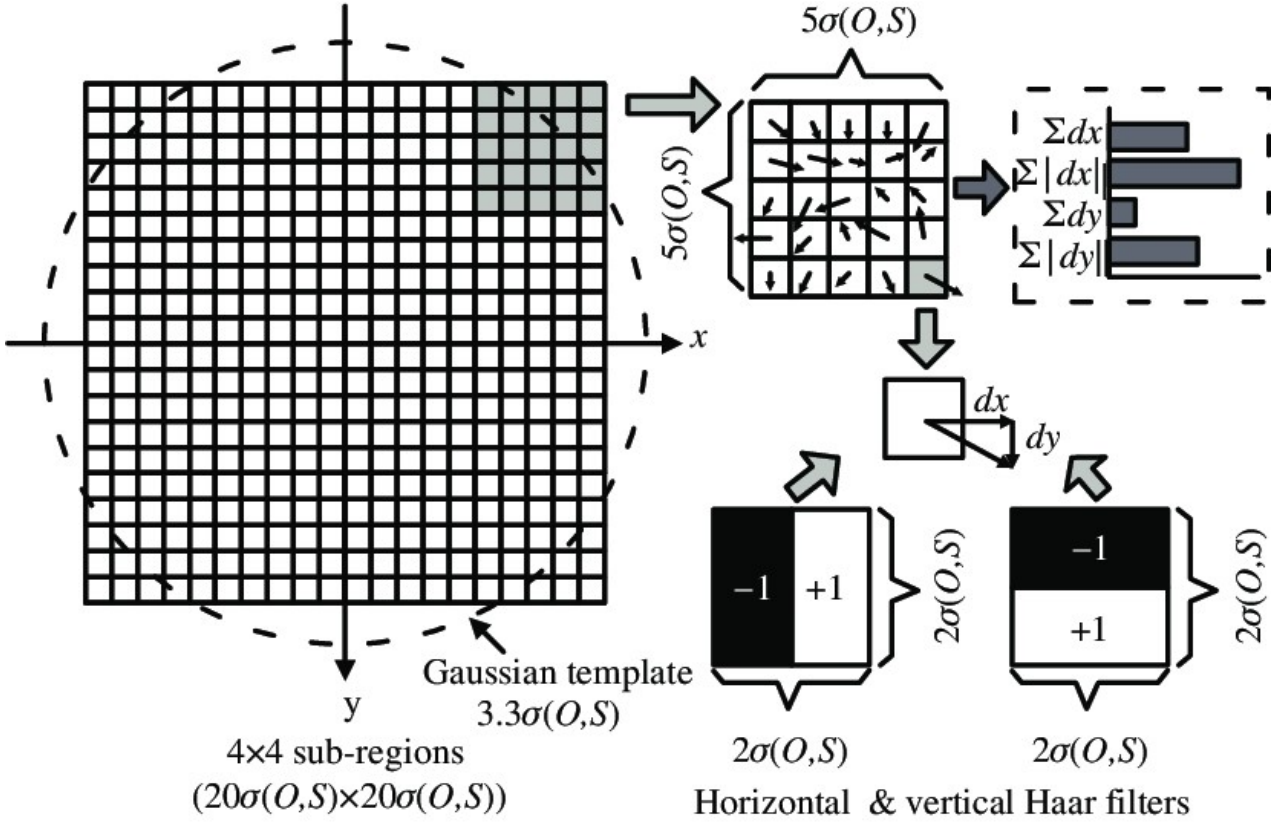
- **PCA-SIFT: A More Distinctive Representation for Local Image Descriptors, CVPR'2004.**





SURF

- **SURF: Speeded Up Robust Features, ECCV'2006**

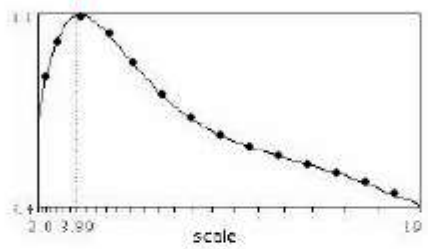


4 x 4 x 4 =64 -vec

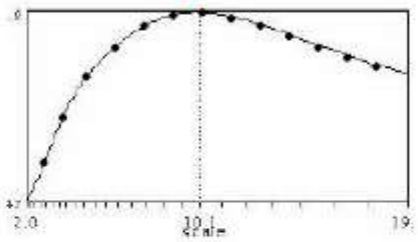
缩放不变 （Scale Invariant）

Automatic Scale Selection

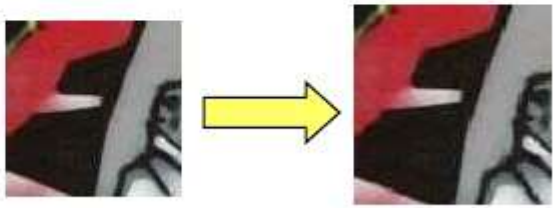
- **Normalize: Rescale to fixed size**

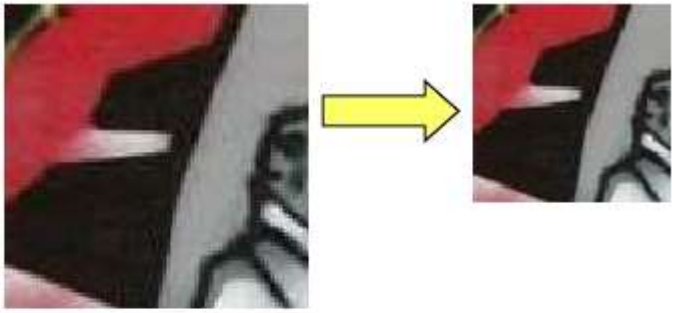


$f(I_{i1\ldots im}(x,\sigma))$



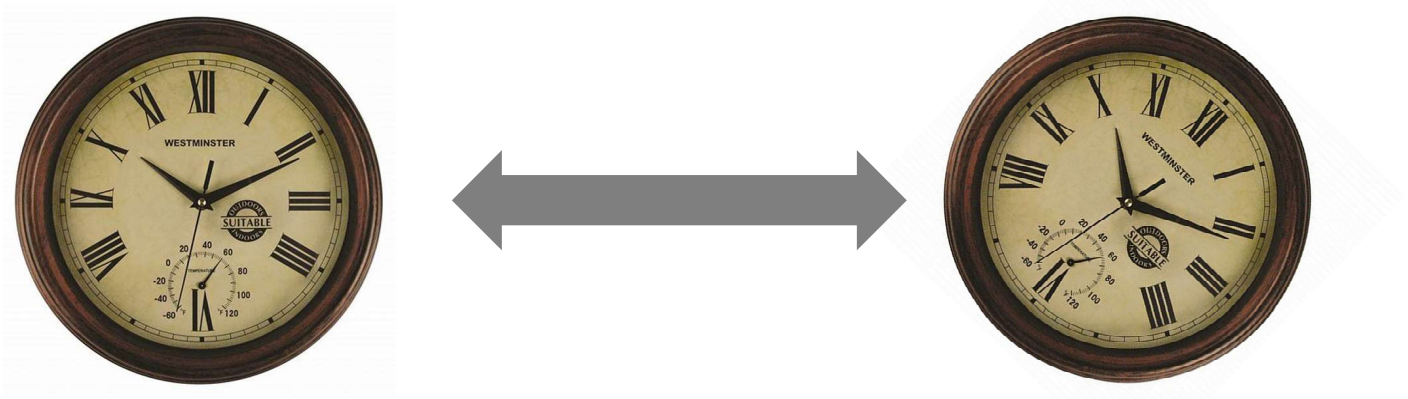
$f(I_{i1\ldots im}(x',\sigma'))$





Slide credit: Tinne Tuytelaars

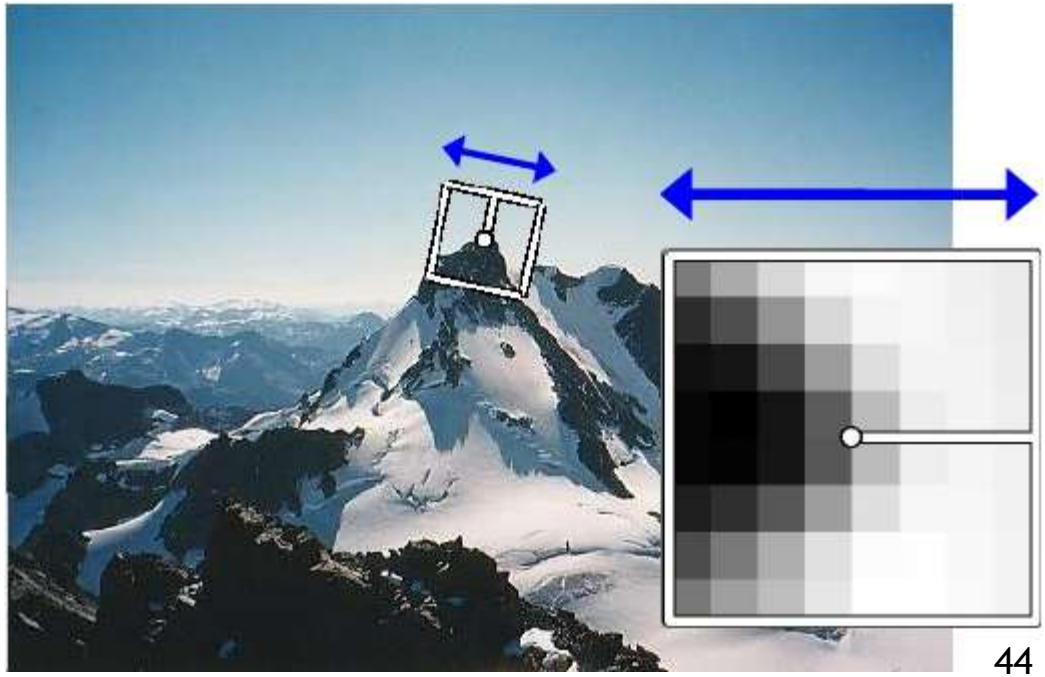
旋转不变 （Rotation Invariant）



Rotation Invariant Descriptors

- Find local orientation
  - Dominant direction of gradient for the image patch

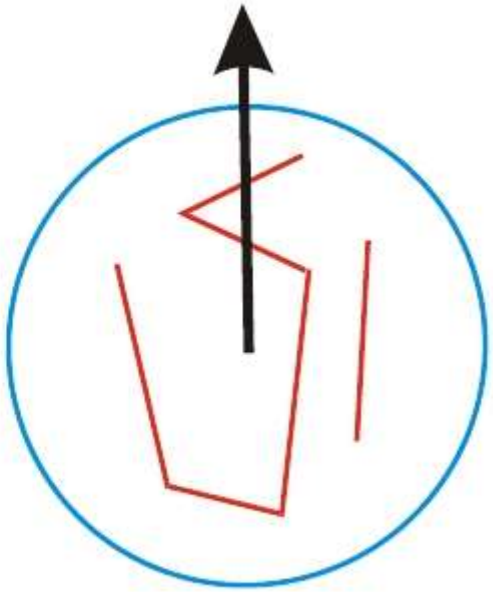
- Rotate patch according to this angle
  - This puts the patches into a canonical orientation.

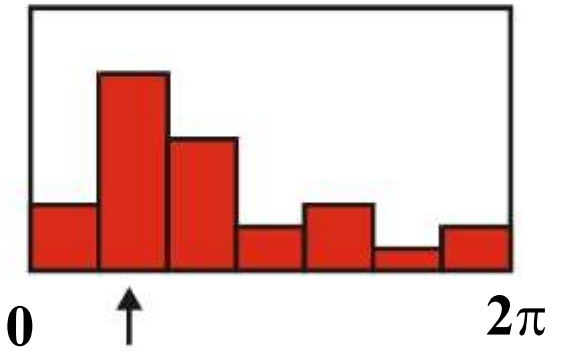


Slide credit: Svetlana Lazebnik, Matthew Brown

SIFT主方向

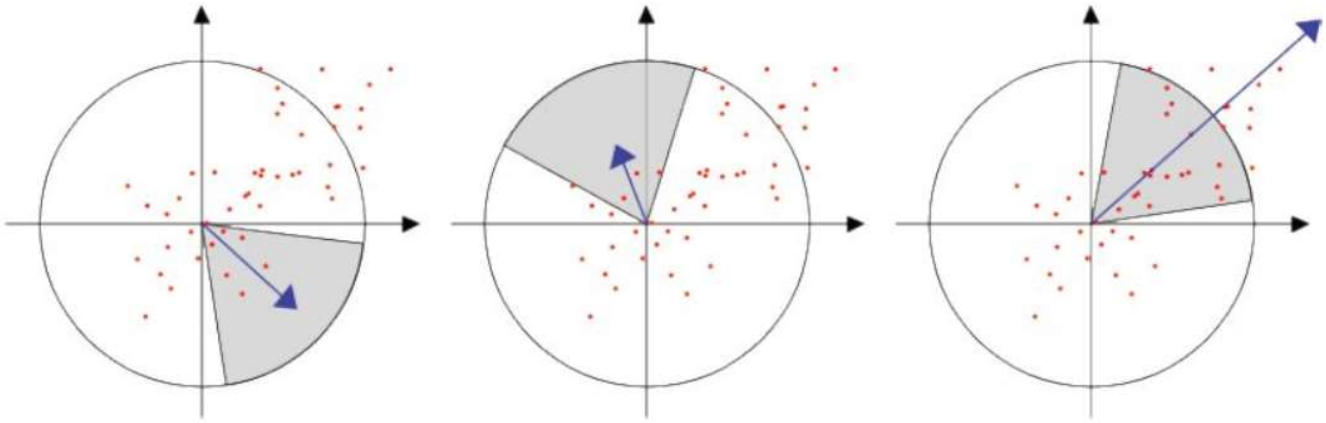
- Compute orientation histogram
- Select dominant orientation
- Normalize: rotate to fixed orientation





Slide adapted from David Lowe

SURF主方向



ORB主方向

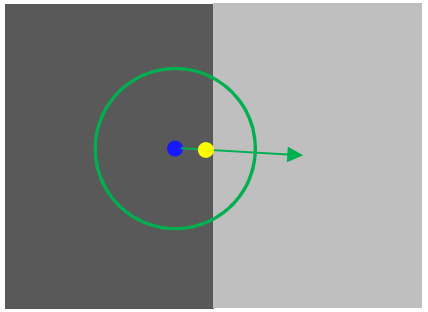
- **ORB: an efficient alternative to SIFT or SURF, ICCV'2011**
- **ORB=Orented-FAST and Rotated BRIEF**

Intensity Centroid (亮度质心):

$$m_{pq} = \sum_{x,y} x^p y^q I(x,y)$$

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}} \right)$$

$$\theta = \text{atan2}(m_{01}, m_{10}).$$



小结

- **SIFT**
  - 基于梯度直方图的主方向和特征描述
- **SURF**
  - 基于小波梯度的主方向和特征描述
- **ORB**
  - 基于亮度质心的主方向+基于**BRIEF**的特征描述

Detector	ORB	SURF	SIFT
Time per frame (ms)	**15.3**	217.3	5228.7

（时间消耗，ORB论文结果)

特征匹配 => 向量搜索

- **BruteForce**
- **Hash-based**
  - **Local Sensitive Hash (LSH)**
- **Tree-based**
  - **Approximate Nearest Neighbor (ANN)**
  - **FLANN library**