Image Processing for Object Recognition

Integrated Seminar Intelligent Robotics

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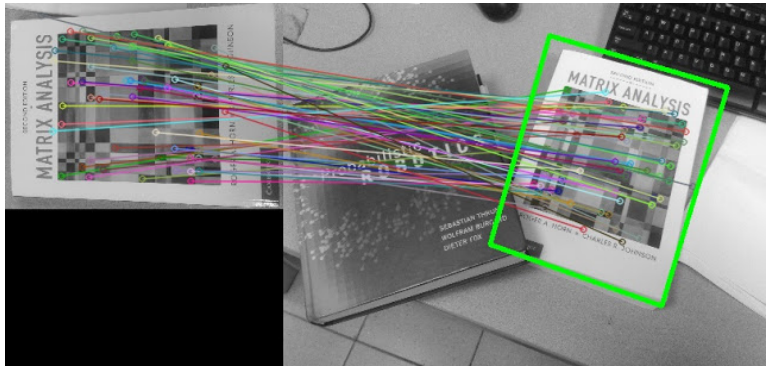
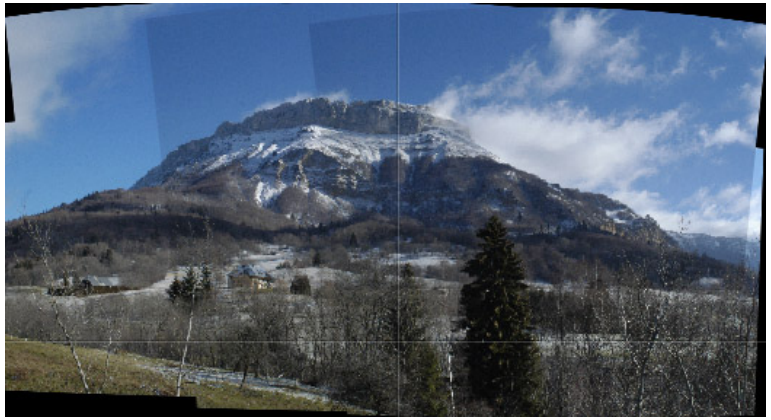
Table of Contents

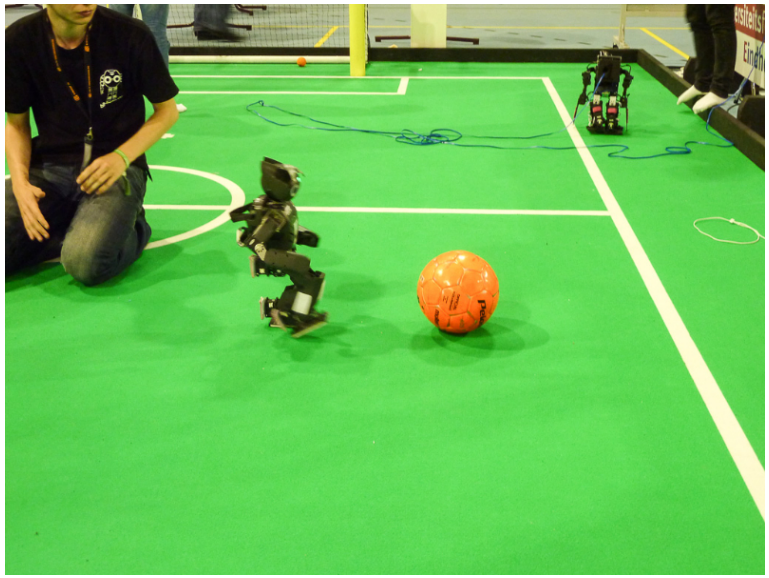
Object Recognition

- Identification of objects
- By sound, touching or image processing
- Faces, pedestrians or objects

Object Recognition







Problem

- Identifying object by pixels is not very useful
  - Different lighting
  - Different color
  - Other perspective
  - Rotated
  - Different scaling
  - ...

What is an Edge?

- An edge is a line
- Change in color, brightness or structure
- Straight or curved

Canny Edge Detector

- Algorithm to detect edges in 2D-images
- By John F. Canny in 1986 [Canny, 1986]
- Can only handle grayscale pictures

Canny Edge Detector

1. Apply Gaussian filter

[Nischwitz, 2011]

Canny Edge Detector

2. Find intensity gradients

[Nischwitz, 2011]

Canny Edge Detector

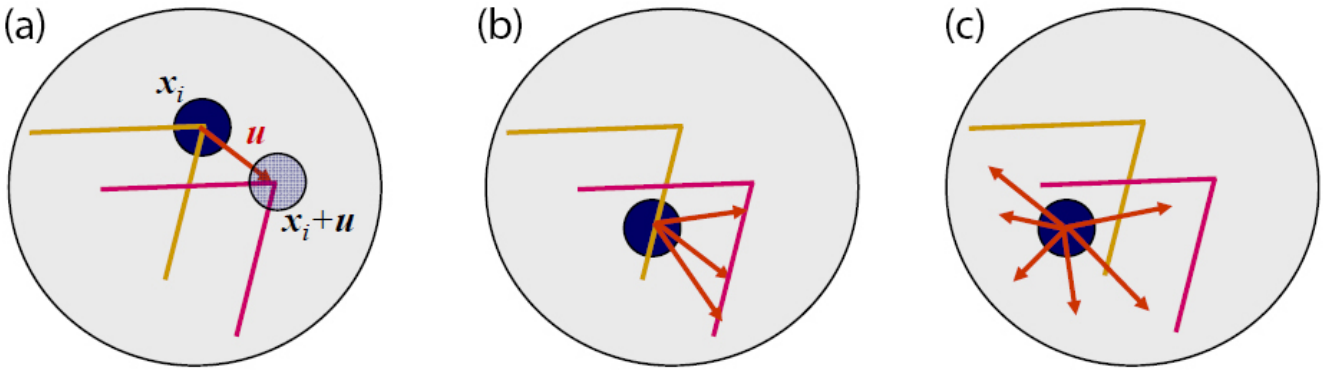
3. Apply non-maximum suppression
4. Apply double threshold
5. Track edges by hysteresis

[Nischwitz, 2011]

Object Recognition by Edges

- Not useful
- Other perspective
- Rotated
- Different objects with same edges

Why not use Edges?



[Szeliski, 2010]

Features

- A feature is a point to describe the object
- Corners
- Crossing of edges
- Regions with constant properties
- Also called interest points

Object Recognition

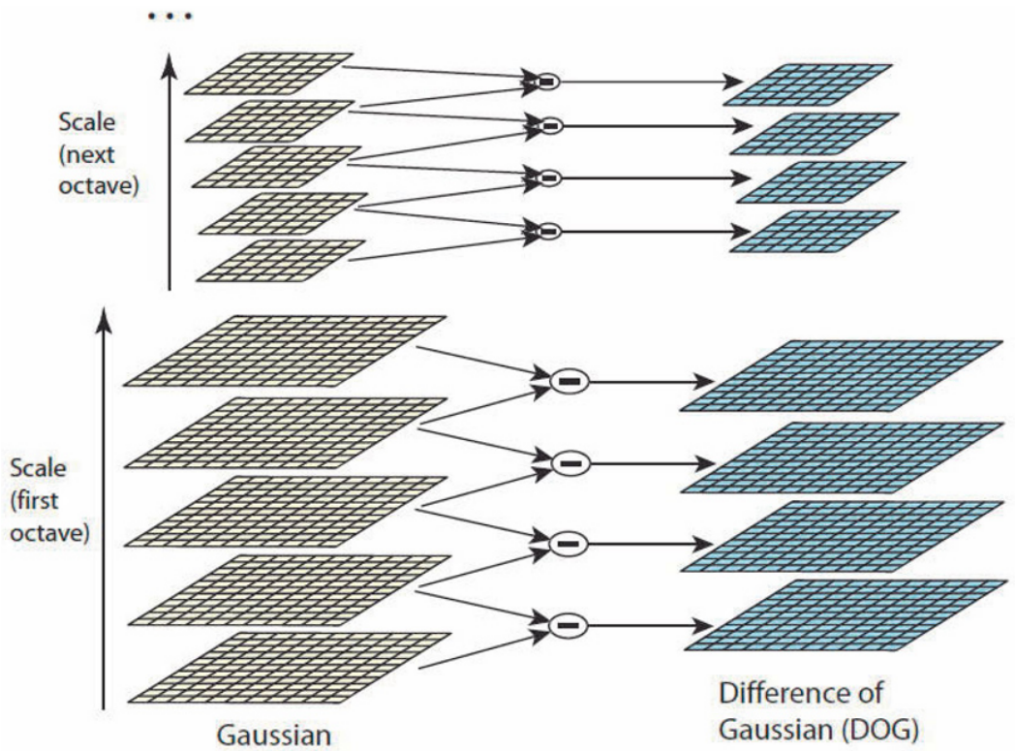
- Feature detection
- Feature description
- Feature matching

SIFT

- Scale Invariant Feature Transform
- By David Lowe in 2004 [Lowe, 2004]
- Can handle:
  - Different scales
  - Changes in viewpoint
  - Rotation
  - Noise
  - Different illumination

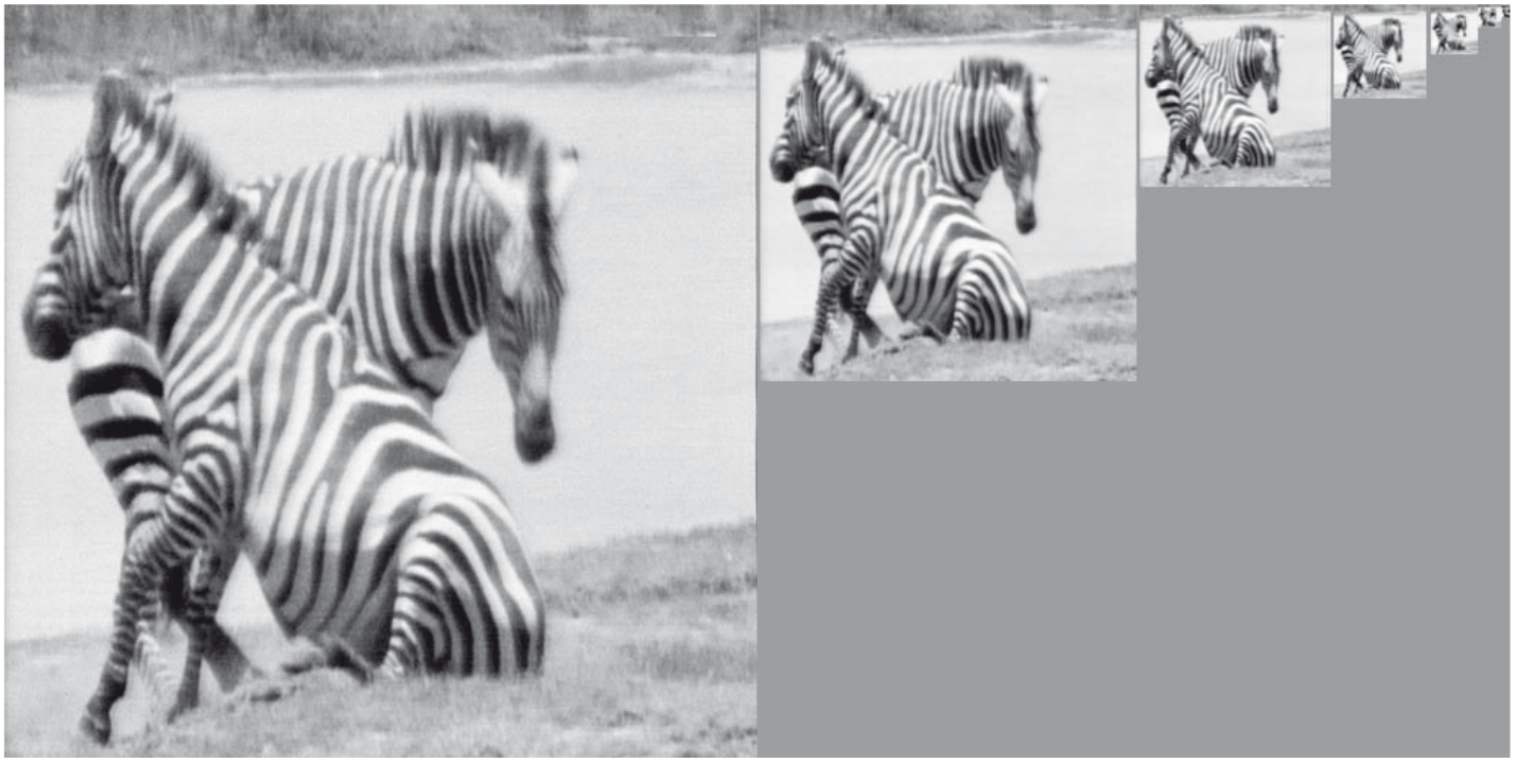
Feature Detection

- SIFT uses the difference of Gaussian(DoG)



[Lowe, 2004]

Feature Detection

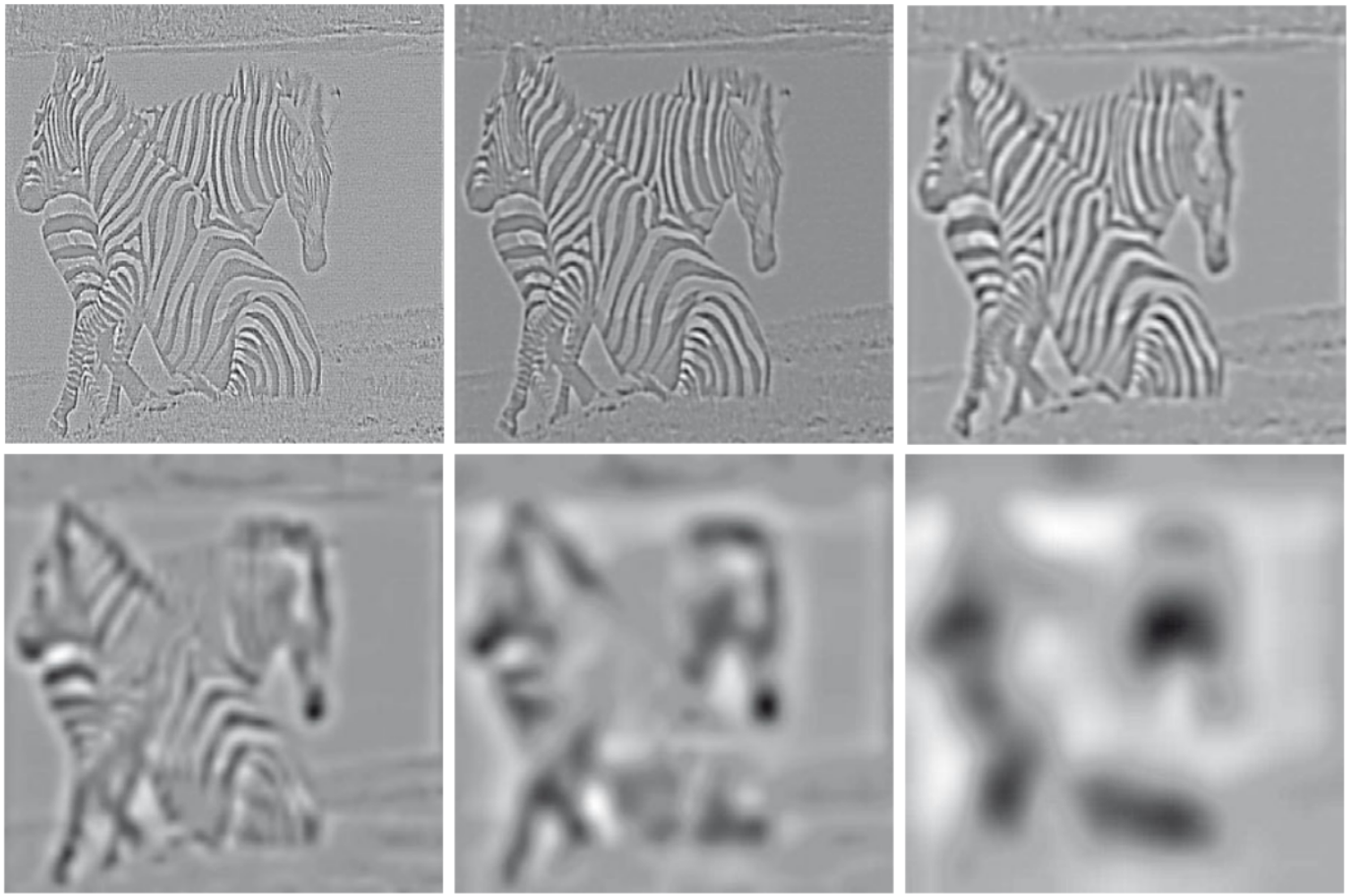


[Nischwitz, 2011]

Feature Detection

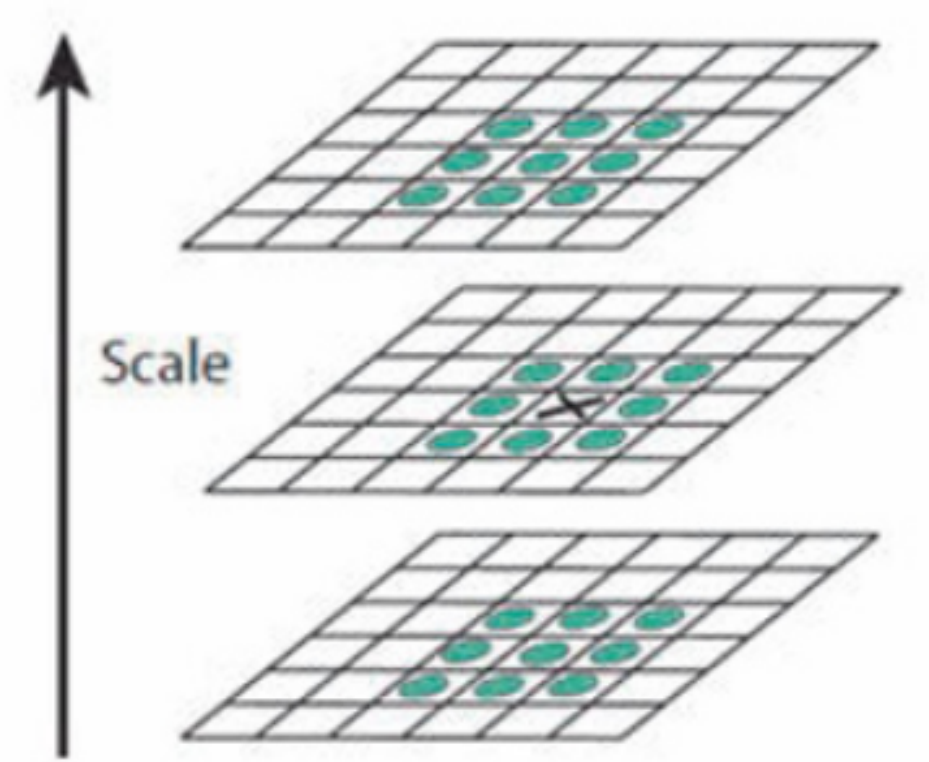
[Nischwitz, 2011]

Feature Detection



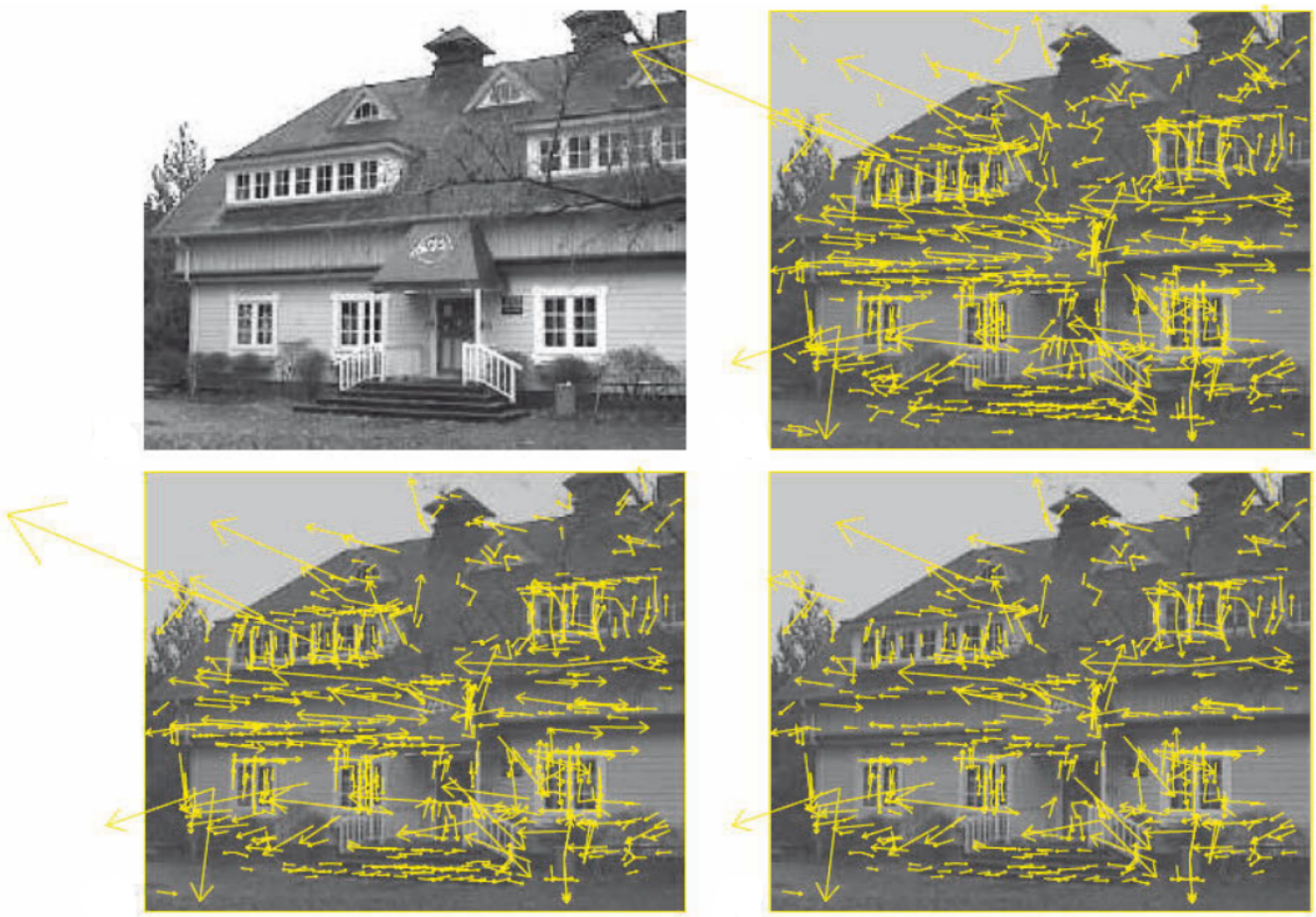
[Nischwitz, 2011]

Feature Detection



[Lowe, 2004]

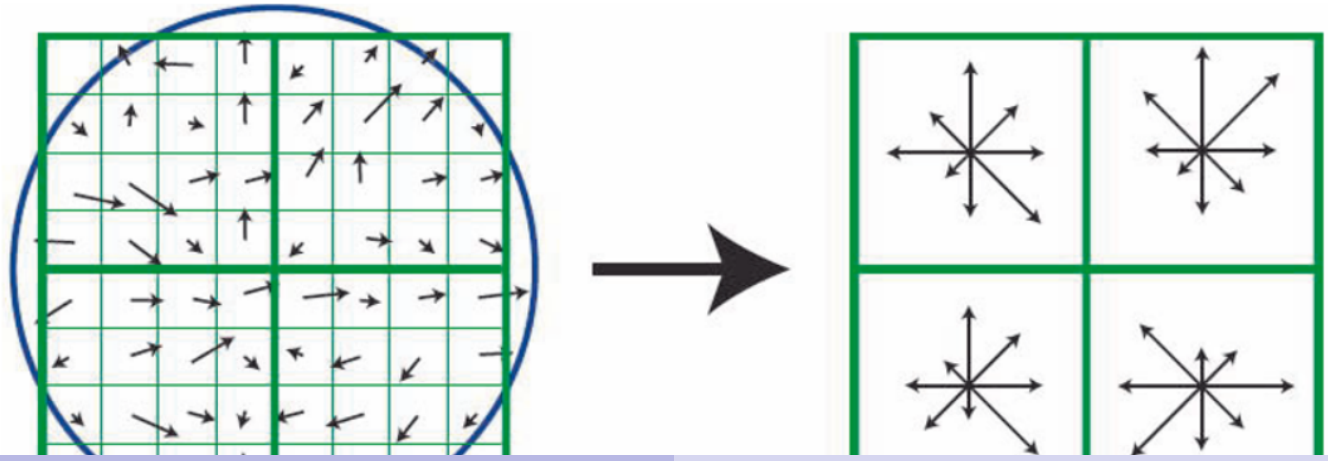
Feature Detection



[Nischwitz, 2011]

Feature Description

- 16x16 pixels around keypoint
- 4x4 groups with 4x4 pixels
- For each pixel: gradient with 36 directions
- Grouped with 8 directions
- Normalized and saved in 128 dimensional vector



Feature Matching

- Compared by Euclidean distance
- Second closest at least 20% away

[Lowe, 2004]

SURF

- Speed Up Robust Features
- By Herbert Bay, et al. in 2006 [Bay et al., 2006]
- Can handle:
  - Different scales
  - Changes in viewpoint
  - Rotation
  - Noise
  - Different illluminations

Feature Detection

- SIFT uses the determinant of Hessian(DoH)

1. Calculate an integral image

$$I_{\sum}(x,y) = \sum_{i=0}^{i \leq x} \sum_{j=0}^{j \leq y} I(i,j)$$

Original

5	**2**	**3**	4	1
1	**5**	**4**	2	3
2	2	1	3	4
3	5	6	4	5
4	1	3	2	6

Integral

5	7	10	14	15
6	13	**20**	26	30
8	17	25	34	42
11	25	39	52	65
15	30	47	62	81

Feature Detection

2. Calculate Hessian matrix

$$H(x,\sigma) = \begin{pmatrix} L_{xx}(x,\sigma) & L_{xy}(x,\sigma) \\ L_{xy}(x,\sigma) & L_{yy}(x,\sigma) \end{pmatrix}$$

- The determinant can measure local change
- Points are chosen when the determinant is maximal

Feature Detection

- Scale is implemented by box filters
- Sizes: 9x9, 15x15, 21x21, 27x27 ...

Feature Description

Orientation

- circular area around the feature point
- Oriented with a Haar wavelet responses that is weighed by a Gaussian function
- The longest Vector defines the orientation of the feature

Feature Description

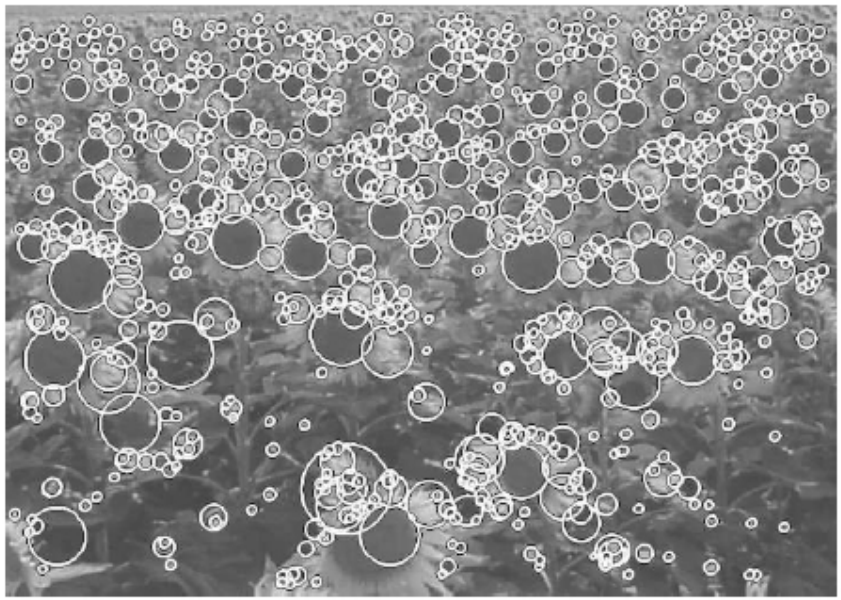
Description

- Square region around the feature
- Oriented along the orientation
- Split into 16 regions (4x4)
- Haar wavelet responses with 5x5 sample points for each region
- Summed up to a 4 dimensional vector
- All vectors combined to 64 dimensional vector weighed by a Gaussian function

Feature Description

Description

(a)



(b)

[Bay et al., 2006]

Feature Matching

- Compared by Euclidean distance
- Second closest at least 20% away

Bibliography I

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