SIFT

Scale Invariant Feature Transform

Introduction

- SIFT: Scale-invariant feature transform.
- SIFT method was developed in the early 2000s.
- Its accuracy and robustness were significantly higher than previous template matching methods.
- Its extensions/modifications (PCA-SIFT, ASIFT, SURF, ORB, BRIEF, etc.) are very popular and applied even in the age of deep learning.
  - even if nowadays deep-learning is the most popular;
  - e.g. SuperPoints/SuperGlue.

Steps of SIFT feature matching

As it is usual, two main steps form the method

1. Feature Detection
   a. ↠ descriptor
2. Feature Matching

Feature detection

1. Scale space
    - due to scale invariance
2. Difference of Gaussian (DoG) operator
    - for measuring
3. Orientation estimation
    - histogram from gradient orientation

Scale space

Image are rescaled to several variants

- Here, 100%, 75%, 50%, 25% are visualized

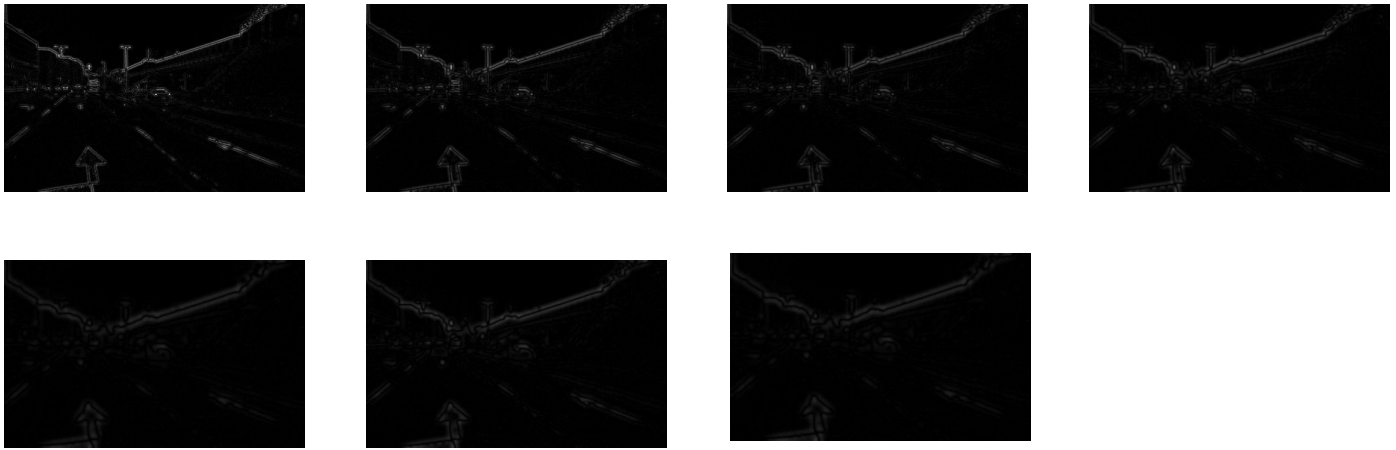
Gaussian Filtering

Gaussian filtering with increasing sigma




Difference of Gaussians (DoG)

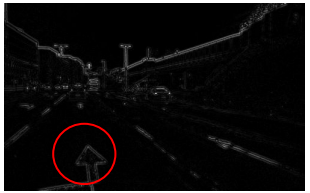
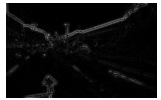
Here are some examples for the differences:



DoGs at different scales

Peak selection

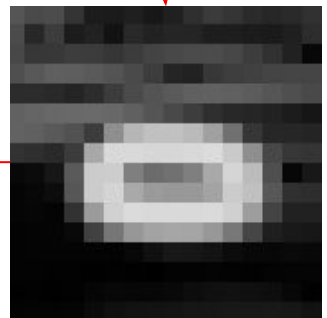


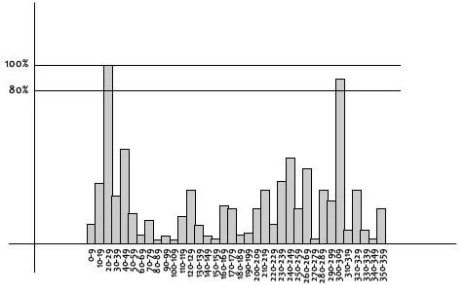



Orientation estimation

The patch around keypoint location selected

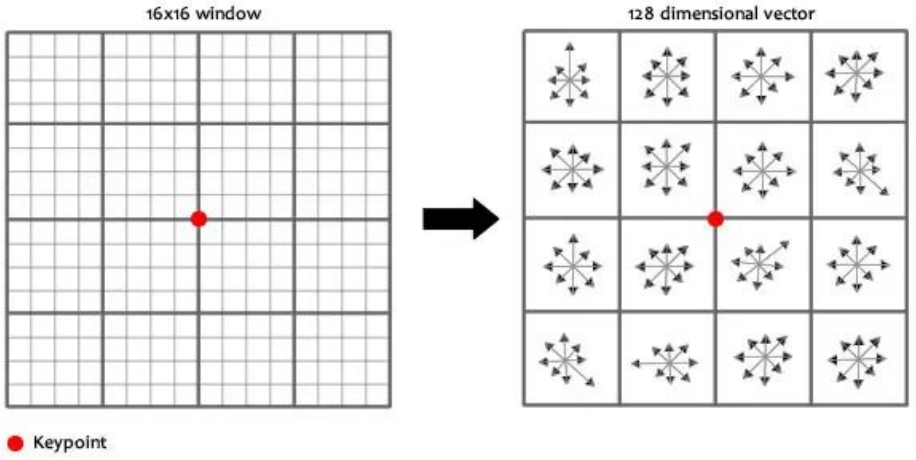
- gradient orientation computed
  - using Prewitt or Sobel operator
- Histogram created from gradient direction
  - 36 bins applied
  - 0˚-9˚, 10˚-19˚,..., 350˚-359˚
- Peak gives orientation of the patch
  - 80% rule: if second peak is close, keypoint deleted.





Keypoint descriptor

- 16x16 pixel patches applied
  - divided into 4x4 patterns
- Histogram for orientation of sub-patterns
  - 8 bins / pattern
- Feature described by 128D vector
  - Containing every histogram value
  - 4x4x8=128



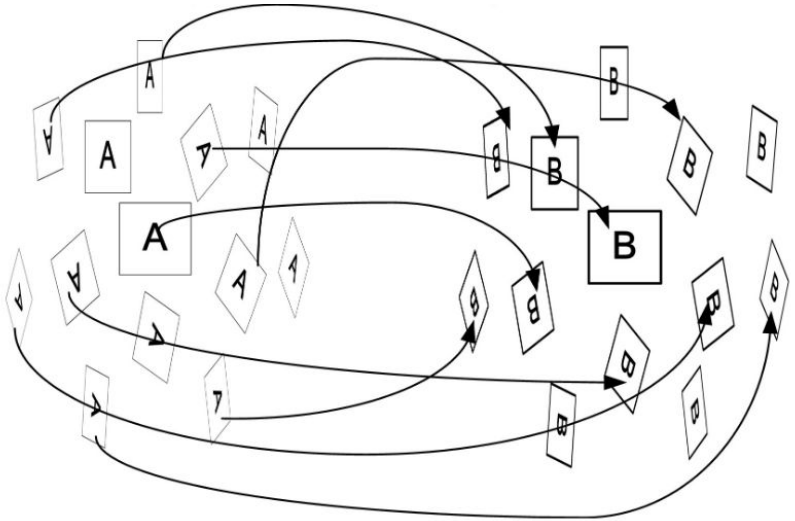
Imag from medium.com

Keypoint matching

- 128D vectors simply compared between images
  - difference between vectors (absolute value)
- 80% rule again
  - score differences for second best target higher than 80% score of best match
  - features discarded

Trivial modifications: Affine SIFT

- Images transformed by several affine transformations (ATs)
- ATs simulate viewpoint difference
  - Then SIFT applied



Example

- Affine transformation between images
  a. ORB features
     - initial scales and angles obtained
  b. brute force template matching
     - varying scale and angles
  c. Lucas-Kanade method for final refinement

Thank you for your attention