Robot Vision: Features

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Outline

- The importance of feature matching
- Image similarity and viewpoint changes
- Challenges
- Properties of detectors and descriptors
- Detectors
  - What locations would be good
  - Point detectors (concept of Harris and FAST)
  - Blob detectors (DOG)
Image features

- The term “feature” or “image feature” is used with some variety of meaning.

- Set of properties, description of an image region (in this case including a specific location) or the whole image

- Strictly speaking the term “feature” only means a description, but any description needs a location. So the wider definition also means a location and region

- “Feature points” are the detected point locations in images that are used for image matching or geometric algorithms.

- Image features are a combination of the results of a detector method and a descriptor method.
The importance of feature matches

- Geometric algorithms need point correspondences i.e. image feature matches.
- The quality of feature matches determines the outcome of geometric algorithms.
  - Location accuracy of feature matches
  - Correctness of feature matches (mis-matches)
- Image classification, image indexing, image search, image interpretation also need feature points and feature matches.
Image similarity and viewpoint changes
Image similarity and viewpoint changes
Two challenges

- How to select proper points (detectors)
- How to compute the similarity of image patches (descriptor)
Properties of detectors

- Accurate localization
- Useful locations
- High repeatability detection
Properties of descriptors

- Discriminative
- Descriptive
- Compact descriptions
- Invariance to image changes (brightness, rotation)
Detectors: Which locations would be good

- homogeneous area
- edge
- corner
Detectors

- Point detectors
  - Harris corners
  - FAST corners
- Blob detectors
  - DOG points
Harris corners

- Looks for locations in an image where the SSD changes strongly

\[
f(x, y) = \sum_{(x_k, y_k) \in W} (I(x_k, y_k) - I(x_k + \Delta x, y_k + \Delta y))^2
\]

\[
f(x, y) \approx (\Delta x \quad \Delta y) M \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}
\]

\[
M = \sum_{(x,y) \in W} \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \sum_{(x,y) \in W} I_x^2 & \sum_{(x,y) \in W} I_x I_y \\ \sum_{(x,y) \in W} I_x I_y & \sum_{(x,y) \in W} I_y^2 \end{bmatrix}
\]
FAST corners

- Count the number $N$ of contiguos pixels around a center pixel $p$ that are brighter than the center pixel. If $N \geq$ than some threshold this point is a feature location.
Harris corners vs. Fast corners
Harris corners vs. Fast corners

- Slower to compute
- Better control of number of detections with threshold

- Fast to compute
- Many detections
- Many corners next to each other
Difference of Gaussian (DOG) points

- Is a Blob detector, detections are not necessarily on image corners
- Is a scale invariant detector, high repeatability even for images of different scales (image resolution)
- Processes images at different resolutions (scales) and then selects a feature location in x,y and a specific scale s which has a high value for the sum of the squares of the second derivatives in all directions (Laplacian)
Filter mask is composed of the subtraction of two Gaussian filter masks
Is an approximation of the Laplace operator (Laplacian of Gaussian, LOG) which is a blob detector

\[ \text{DOG}(x, y) = \frac{1}{k} e^{-\frac{x^2+y^2}{(k\sigma)^2}} - e^{-\frac{x^2+y^2}{\sigma^2}} \]
Computation of DOG’s measure

$2^2 \sigma_0 \uparrow$

second
octave

$\sigma_0$
downsampling (half resolution)

$2 \sigma_0 \uparrow$

first
octave

$\sigma_0$

Gauss filtered images

Difference of Gauss filtered images
Selection of extrema

- Extrema are selected in 3D (x,y,scale)
- Center pixel needs to be larger or smaller than its 26 neighbors
DOG feature points