Affine invariance


Similarly to characteristic scale selection, detect the characteristic shape of the local feature
Affine adaptation

\[ M = \sum_{x,y} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = R^{-1} \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix} R \]

We can visualize \( M \) as an ellipse with axis lengths determined by the eigenvalues and orientation determined by \( R \).

**Ellipse equation:**

\[ \begin{bmatrix} u \\ v \end{bmatrix} M \begin{bmatrix} u \\ v \end{bmatrix} = \text{const} \]

The second moment ellipse can be viewed as the “characteristic shape” of a region.
Rotation preserves eigenvalues, so affine deformations are upto rotation.
Affine adaptation

- Detect initial region with Harris Laplace
- Estimate affine shape with M
- Normalize the affine region to a circular one
- Re-detect the new location and scale in the normalized image
- Go to step 2 if the eigenvalues of the M for the new point are not equal [detector not yet adapted to the characteristic shape]

The rotation ambiguity is eliminated be, say, Scale-Invariant Feature Transform (SIFT).
Affine adaptation

Output: location, scale, affine shape, rotation
From covariant regions to invariant features

Extract affine regions → Normalize regions → Eliminate rotational ambiguity → Compute appearance descriptors

SIFT (Lowe ’04)
Affine adaptation example

Scale-invariant regions (blobs)
Affine adaptation example

Affine-adapted blobs

ellipses of M