Automotive Vision Tutorial

Feature Points

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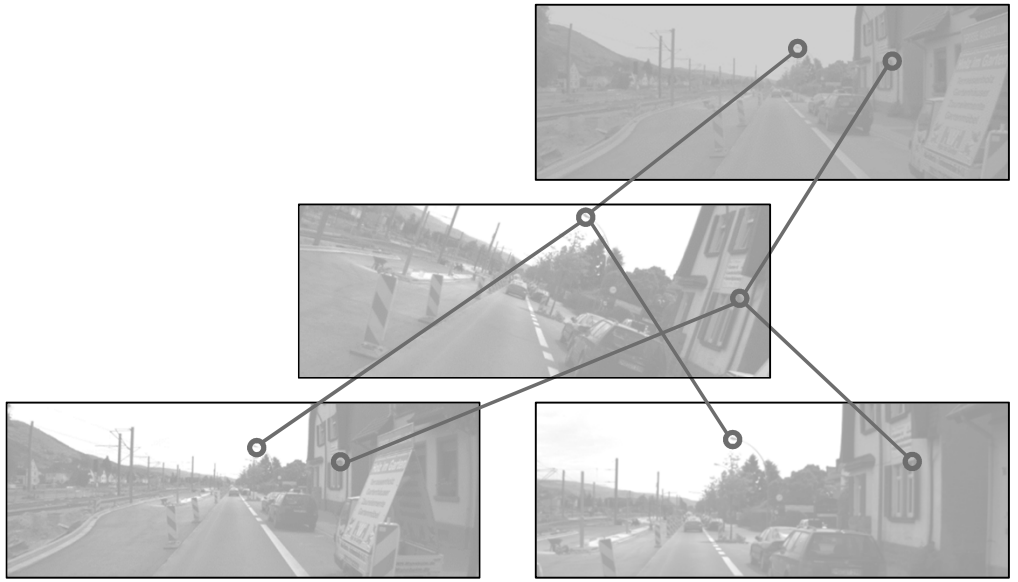


SIFT (Scale Invariant Feature Transform)

Feature Detection

Feature Description

Correspondence and Feature Matching

Feature Detection

Step	in full SIFT	introduced in lecture	used in SIFT light
build scale space function L	with DoG filter	with LoG	with LoG
use image pyramids to build and represent L	yes	yes	no
determine local maxima in L	yes	yes	yes
subpixel refinement (determine maxima position with subpixel accuracy)	yes	no	no
eliminate maxima with low contrast	yes	yes	yes
eliminate maxima next to graylevel edges	yes	yes	yes
eliminate maxima at boundaries	?	no	yes

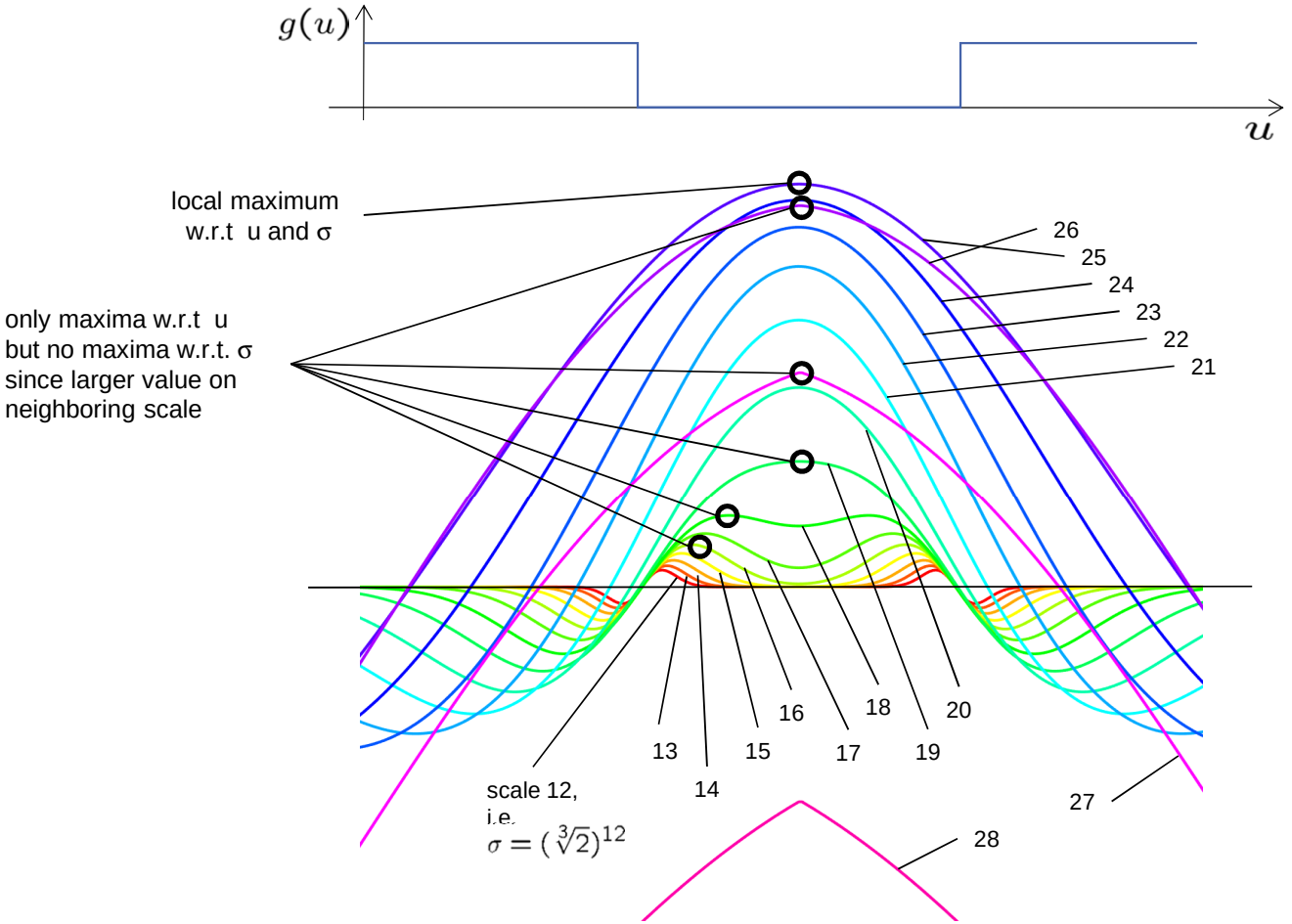
Scale Space Function

Convolve with Laplacian of Gaussian (LoG) with different scales σ

σ_1 ... σ_5 ... σ_{10}

$$L(u, v, \sigma) = \sigma^2 \cdot (g * LoG_\sigma)(u, v)$$

Local Maxima



SIFT-light – Conditions for Feature Points

1. Maxima in local window cube

2. Eigenvalues of the Hessian $H(u, v, \sigma)$ matrix should roughly be the same

$$\frac{Tr^2(H)}{det(H)} < \frac{(r+1)^2}{r}$$

3. Maxima should not be located at boundary of scale space

Hessian Matrix

- Second order partial derivatives of L
- Local curvature of a function with many variables

$$H = \begin{pmatrix} \frac{\partial^2 L}{(\partial v)^2} & \frac{\partial^2 L}{\partial u \partial v} \\ \frac{\partial^2 L}{\partial u \partial v} & \frac{\partial^2 L}{(\partial u)^2} \end{pmatrix}$$

$$\frac{\partial^2 L}{(\partial v)^2} \approx L(v+1,u,\sigma) - 2 \cdot L(v,u,\sigma) + L(v-1,u,\sigma)$$

$$\frac{\partial^2 L}{\partial u \partial v} \approx \frac{1}{4}(L(v+1,u+1,\sigma) + L(v-1,u-1,\sigma) - L(v+1,u-1,\sigma) - L(v-1,u+1,\sigma)$$

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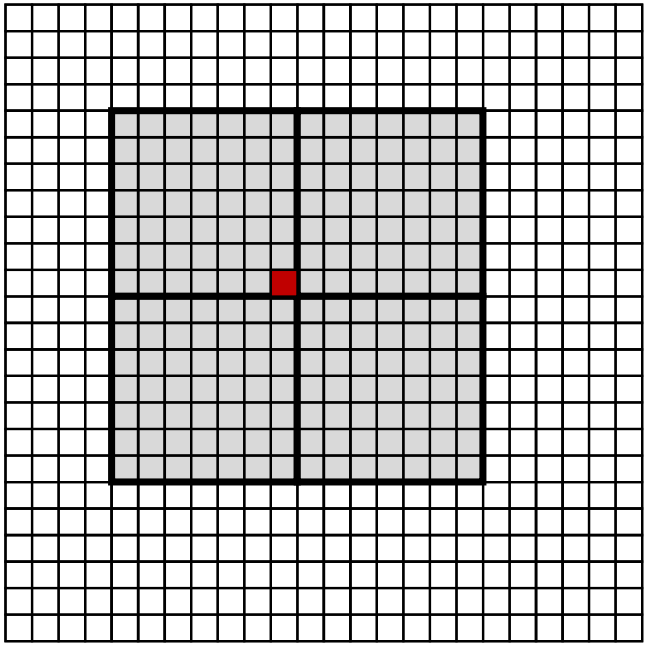
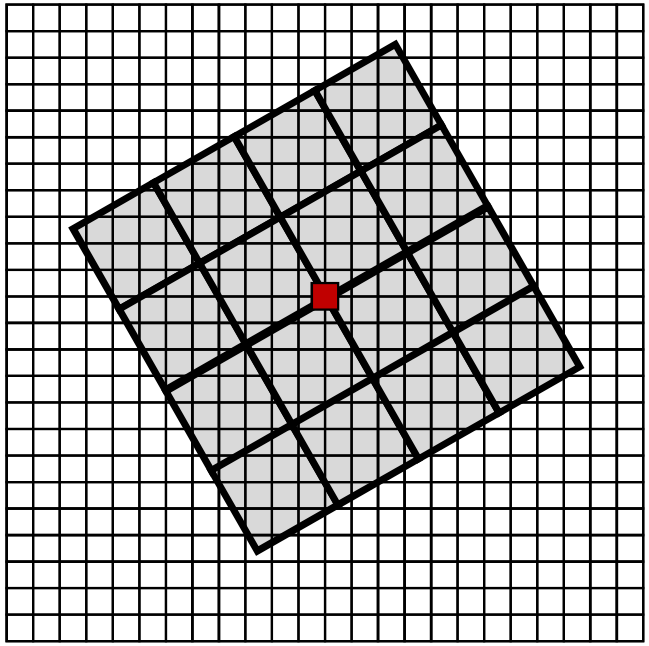
Step	in full SIFT	introduced in lecture	used in SIFT light
weight graylevel gradients by Gaussian	yes	no	no
calculate orientation histogram for environment	yes	yes	no
determine preference direction	yes	yes	no
partition environment into blocks	4-by-4 blocks	2-by-2 / 4-by-4-blocks	2-by-2 blocks (non-rotated)
create orientation histograms for each block	yes	yes	yes
concatenate histograms	yes	yes	yes
normalize descriptor	?	no	yes

Block Structure



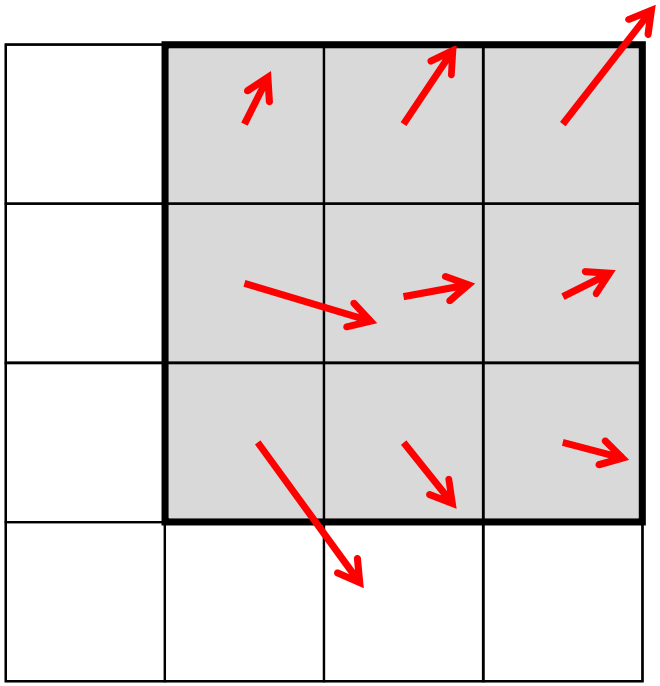
size varies
with σ-value
of maximum

SIFT light
2-by-2 block, non-rotated

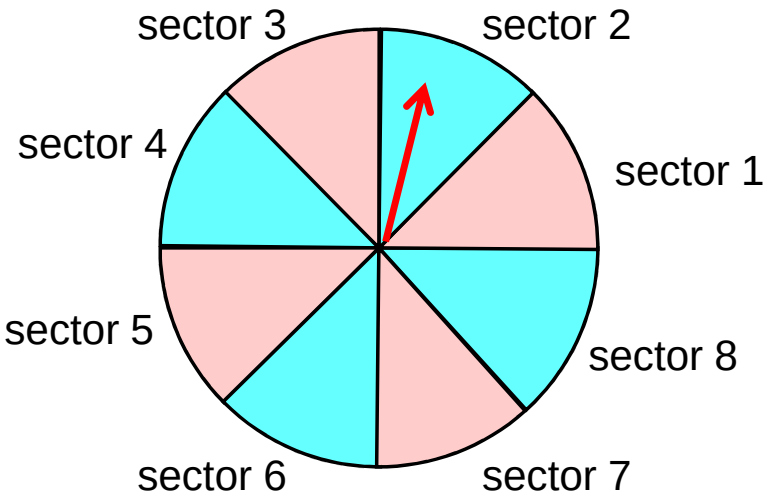


full SIFT
4-by-4 block, rotated
interest point at subpixel position

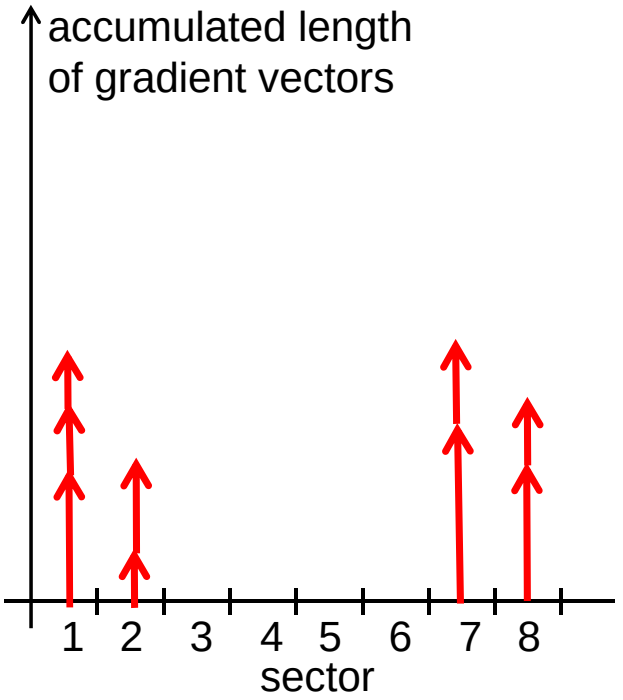
Orientation Histogram



determine graylevel gradients



determine orientation sector



sum gradientlengths for each sector

Feature Matching

Step	used in SIFT light
calculate dissimilarity between pairs of feature points	yes
search pairs of feature points with smallest dissimilarity	yes
eliminate pairs with considerably large dissimilarity	yes

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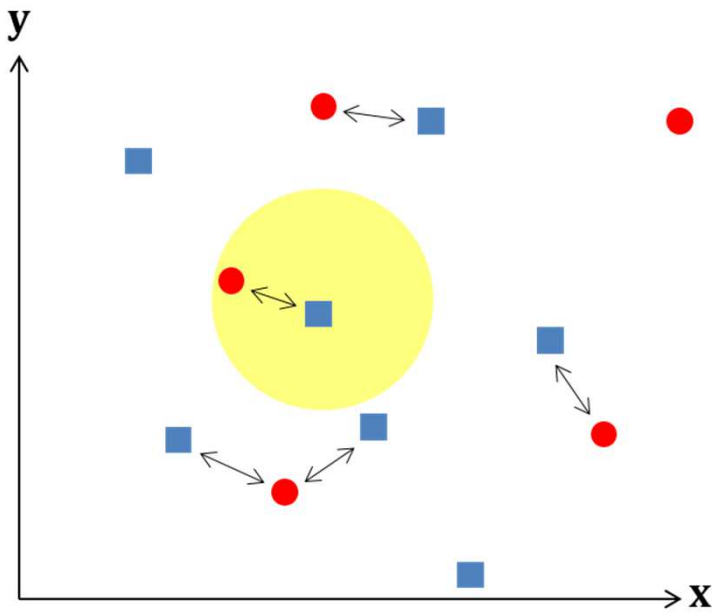
SIFT-light – Nearest Neighbors



- Find corresponding points in neighborhood
- Neighborhood defined in 32-dimensional descriptor space