Distinctive Image Features from Scale-Invariant Keypoints(SIFT)

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Purpose

-We want to Recognize

-For recognizing , need features

-Extract features from image

-Edge detection(Sobel,Canny),Corner detection (Harris)...

-False features due to bad illumunations,different scales, or rotation

-This paper focus extracting distinctive invariant features

-invariant to : image scale and rotation,addition of noise or change in illumunation

Steps

-Scale-space extrema detection

  -Difference of Gaussian over all scales and all locations

-Keypoint localization

-Orientation assignment

  - Image gradient directions

-Keypoint descriptor

Properties

-Near real-time

-For 500X500 pixel about 2000 stable features

-Key point descriptors are highly distinctive , this allow a feature enough to find correct match

Detection of scale-space extrema

-Identify locations and scales

-$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y)$ *: convolution

-L(x,y,σ) : scale space of an image

-G(x,y,σ): Gaussian

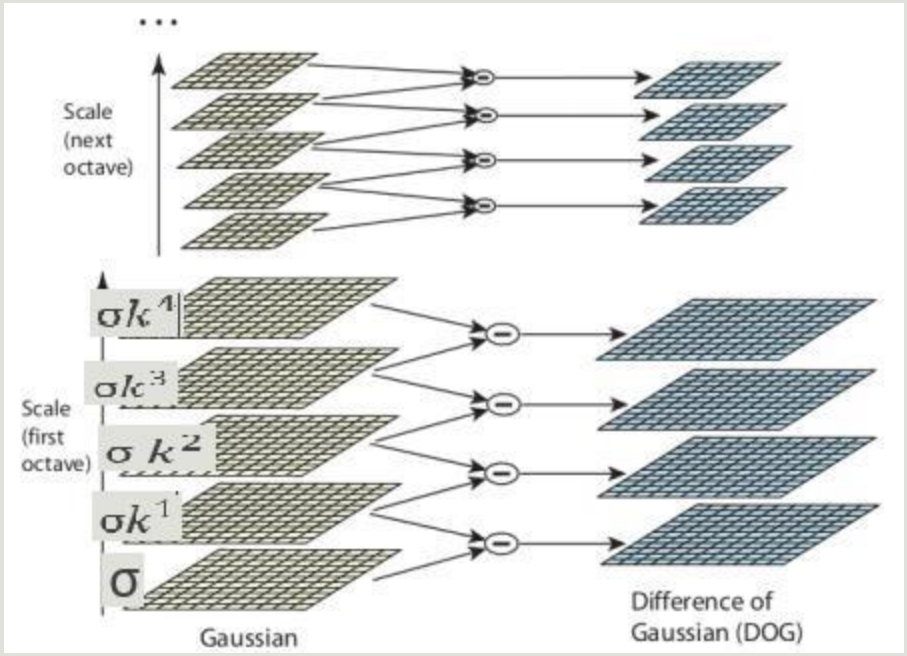
-I(x,y) : Image

-$G(x,y,\sigma) = \frac{1}{2\Pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2}$ Gaussian

Detection of scale-space extrema

-Difference-Gaussian

- $D(x,y,\sigma) = L(x,y,k\sigma) - L(x,y,\sigma)$



$k = 2^{1/s}$ (generally s =2,k=$\sqrt{2}$)

We divide each octave by s+3

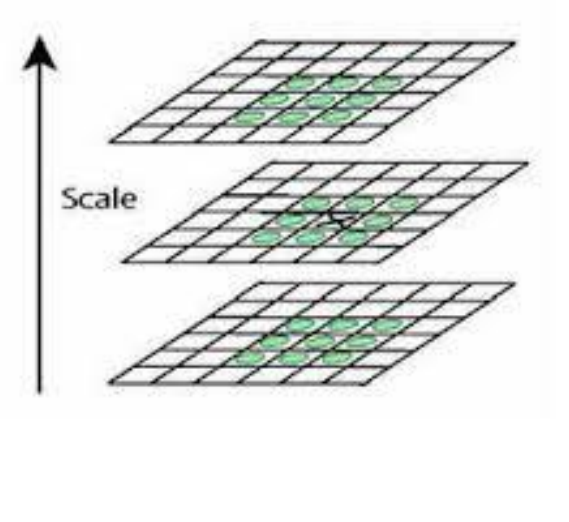
Each octave image = image/2

Detection of scale-space extrema

-Local extrema detection

-4 Scales for per octave (best result)

-Take 3 difference-of-gaussian.



-Compare 8 neighbour and 9 pixels at the top scales and at the bottom 9 pixels.

-If it is higher or less then all of the pixels, it is local extrema point.

Keypoint localization

-Using taylor series DoG can be expand

- $D(\mathbf{x}) = D + \frac{\partial D^T}{\partial x} x + \frac{1}{2} x^T \frac{\partial^2 D}{\partial^2 x^2} x$

  -x = $(x,y,\sigma)^T$

- Extrema can be found with take derivative and set to zero.

- $\bar{x} = -\frac{\partial^2 D^{-1}}{\partial x^2} \frac{\partial D}{\partial x}$ $\quad D(\bar{x}) = D + \frac{1}{2} \frac{\partial D^T}{\partial x} \bar{x}$

- If a extrema with $|D(\bar{x})|$ less than 0.03 were discarded

- Range of image [0,1]

- With this operation , ustable extreama with low constrast can be eliminate

  in an 233X197 image 832 ->729 points

Keypoint localization

-Eliminating edge responses

- $H=\begin{bmatrix} Dxx & Dxy \\ Dxy & Dyy \end{bmatrix}$ H: $Hessian\ Matrix$

- $Tr(H) = Dxx + Dyy = \lambda_1+\lambda_2$ λ_1, λ_2 : eigenvalues

- $Det(H) = DxxDyy -(Dxy)^2 = \lambda_1\lambda_2$

- $\frac{Tr(H)^2}{Det(H)} = \frac{(r+1)^2}{r}$ $\lambda_1 = r.\ \lambda_2$

İf r > 10 eliminate this point

-729->536 points

Orientation assignment

-Compute gradient magnitude and orientation using ;

-$m(x,y) = \sqrt{(L(x+1, y) - L(x-1, y))^2 + (L(x, y+1) - L(x, y-1))^2}$

-$\theta(x,y) = \tan^{-1}((L(x, y+1) - L(x, y-1))/(L(x+1, y) - L(x-1, y)))$

-The orientation histogram has 36 bins

-Highest peak selected from histogram

-if other high nearly %80 of highest create multiple orientation

Image Descriptor

-Last step ; Histogram to Descriptor

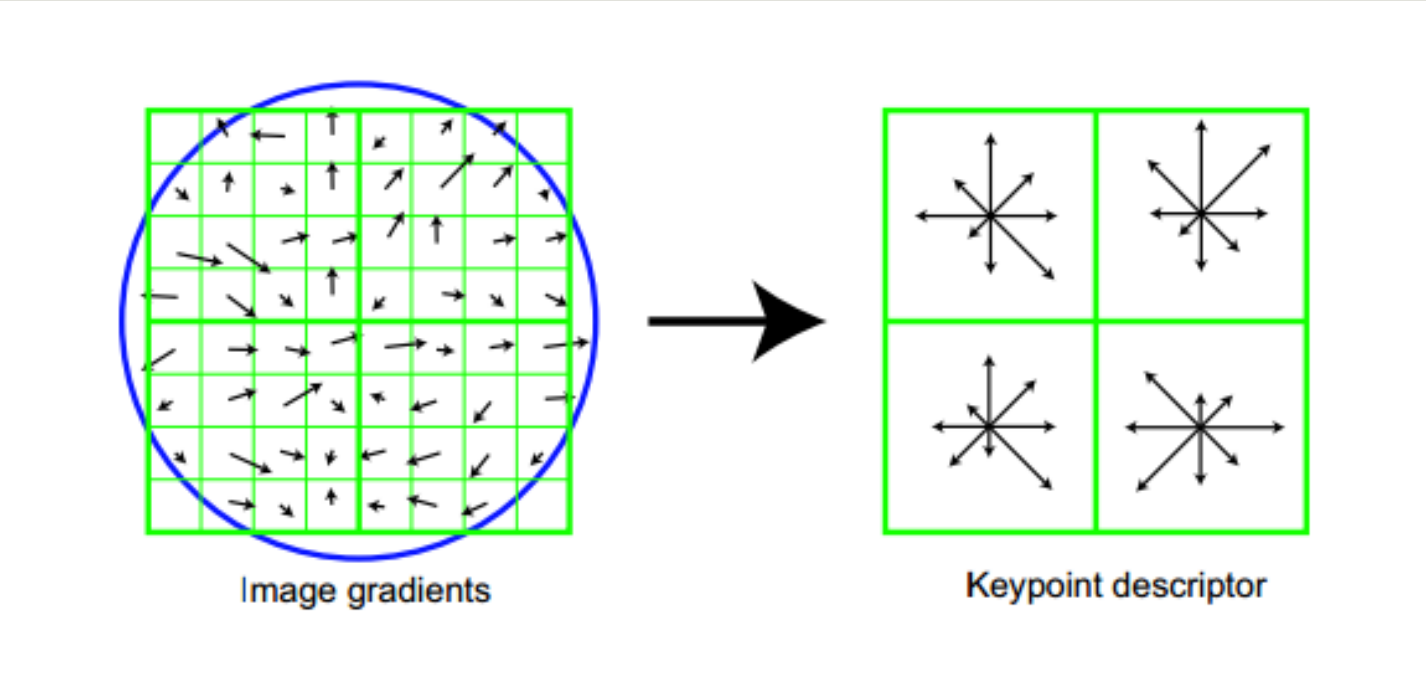


Image Descriptor

-For a key point we have 4X4X8 feauteres vector

-Each vector can be in 8 direction with different magnitude

-Before the transformation we should apply Gaussian to Image Gradient Histogram

References

Distinctive Image Features from Scale-Invariant Keypoints by David G.Lowe taken from :

http://www.cs.berkeley.edu/~malik/cs294/lowe-ijcv04.pdf