EECS 442 Discussion

09/27/2017

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Announcements

- HW 1 is due tomorrow.

Some of the problem needs a submission of original .m files together with the report. Pack them into a single file.

Comment your code and make graders’ life easier.

- Quiz tomorrow.

Covers Tuesday’s lecture.

- Short survey at the end of the discussion.

Provide your feedback and help me do better ☺

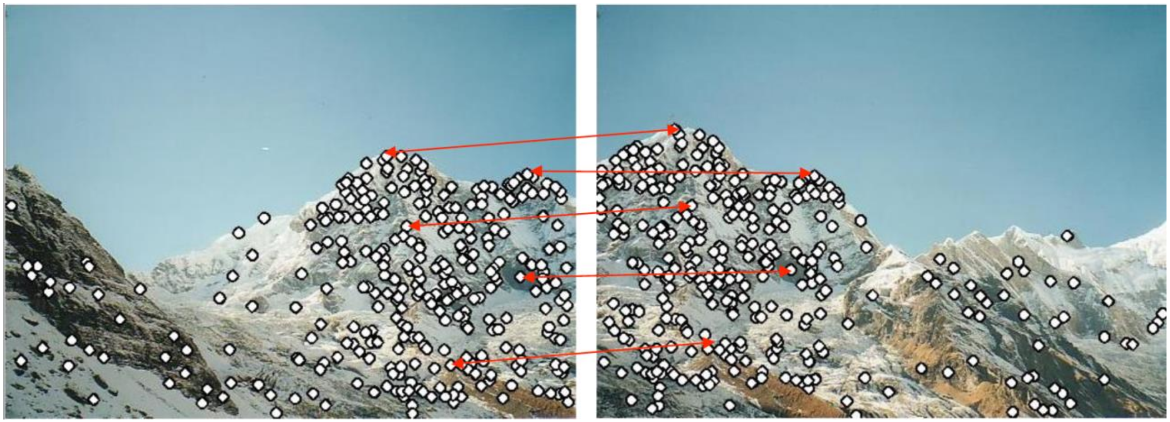
Today's Topics

- Structure tensor and Harris operator
- Application of feature detection: image stitching

Image Stitching

Image Stitching

Image Stitching



1. Find feature points in both images. -> structure tensor *Reduction*

2. Match the feature points into pairs. -> matching algorithm, e.g., Hungarian *Matching*

3. Use pairs to align two images. -> homography *Estimation*

Structure Tensor

$$I \quad (x, y) \rightarrow (x+u, y+v)$$

$$I(x+u, y+v) = I(x,y) + \frac{\partial I(x,y)}{\partial x} u + \frac{\partial I(x,y)}{\partial y} v + \underbrace{- - -}_{\text{higher order}}$$

$$E = \sum_{(x,y)\in W} \left(I(x+u, y+v) - I(x,y) \right)^2$$

$$\simeq \sum \left(I(x,y) + \frac{\partial I(x,y)}{\partial x} u + \frac{\partial I(x,y)}{\partial y} v - I(x,y) \right)^2$$

$$= \cancel{\Sigma} \left((u,v) \begin{bmatrix} \sum I_x(x,y)^2 & \sum I_x(x,y) I_y(x,y) \\ \sum I_x(x,y) I_y(x,y) & \sum I_y(x,y)^2 \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} \right)$$

H structure tensor

Structure Tensor

$$H = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$$

$$\det[H - \lambda I] = \det\begin{bmatrix} h_{11}-\lambda & h_{12} \\ h_{21} & h_{22}-\lambda \end{bmatrix} = 0$$

$$(h_{11}-\lambda)(h_{22}-\lambda) - h_{21}h_{12} = 0$$

$$\lambda^2 - (h_{11}+h_{22})\lambda + h_{11}h_{22} - h_{21}h_{22} = 0 \qquad \lambda = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$\lambda_1 = \frac{1}{2}\left(h_{11}+h_{22} \pm \sqrt{(h_{11}+h_{22})^2 - 4(h_{11}h_{22} - h_{21}h_{22})}\right)$$

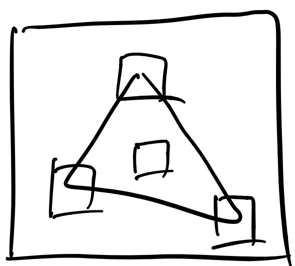
Not positive/negative

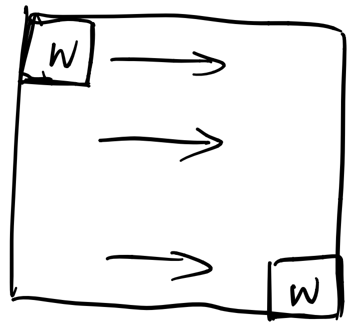
But large/small

Structure Tensor

Structure Tensor

1. Local feature





2. Kernel operator

- Ix, Iy don't change when moving the window. => Precalculated by using kernel
  In HW, pad zeros to handle boarders.

conv "same"

- Also possible to do summation with kernel.

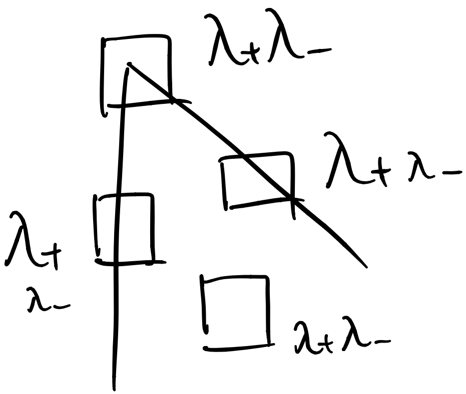
Structure Tensor

3. Harris detector

① λ_-

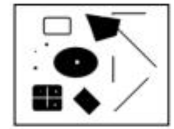
② $$\frac{\lambda_+\lambda_-}{\lambda_+ + \lambda_-} \propto \lambda_-$$

$$= \frac{\det(H)}{\mathrm{Tr}(H)} \checkmark$$



rotation invariant

Harris Example



$$\mu(\sigma_I, \sigma_D) = g(\sigma_I) * \begin{bmatrix} I_x^2(\sigma_D) & I_x I_y(\sigma_D) \\ I_x I_y(\sigma_D) & I_y^2(\sigma_D) \end{bmatrix}$$

1. Image derivatives (optionally, blur first)

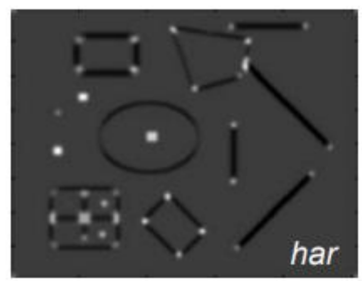
2. Square of derivatives

$$\det M = \lambda_1 \lambda_2$$
$$\operatorname{trace} M = \lambda_1 + \lambda_2$$

3. Cornerness function – both eigenvalues are strong

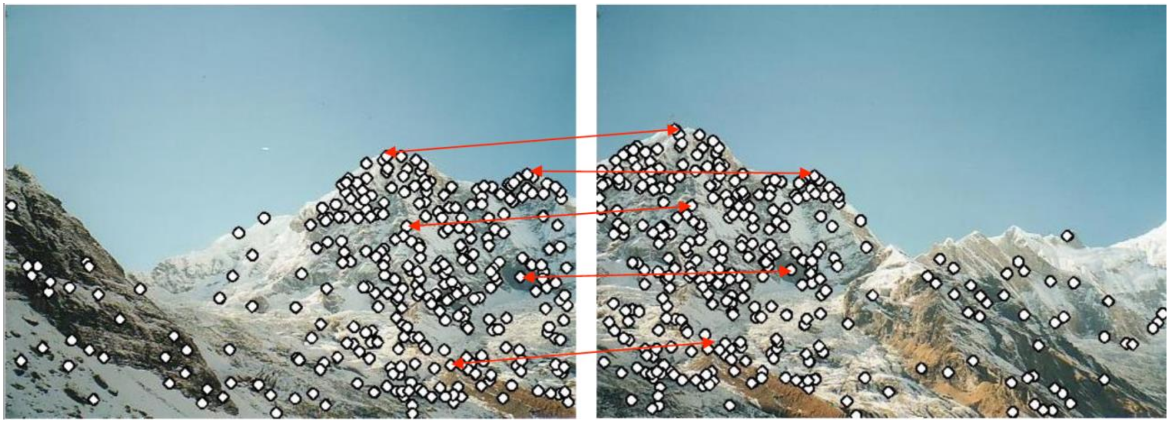
Compute f

4. Non-maxima suppression



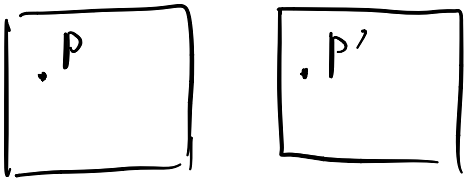
Cornell CS4670
http://www.cs.cornell.edu/courses/cs4670/2015sp/lectures/lec07_harris_web.pdf

Image Stitching



1. Find feature points in both images. -> structure tensor ✓
2. Match the feature points into pairs. -> matching algorithm, e.g., Hungarian ✓
3. Use pairs to align two images. -> homography

Image Stitching



$$p' = Hp$$

$$H = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{bmatrix}$$

$$\underbrace{\min \| p' - Hp \|_2^2}_{\text{Homography}}$$

Recall line fitting

$$y = Ax$$

$$\begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_1 & 1 \\ \vdots & \vdots \\ x_n & 1 \end{bmatrix} \begin{bmatrix} m \\ b \end{bmatrix}$$

$$\min \| y - Ax \|_2^2$$