CLASE 4 : KEY POINTS DETECTION → HARRIS
→ SIFT

• PLAN : (I) MOTIVATION

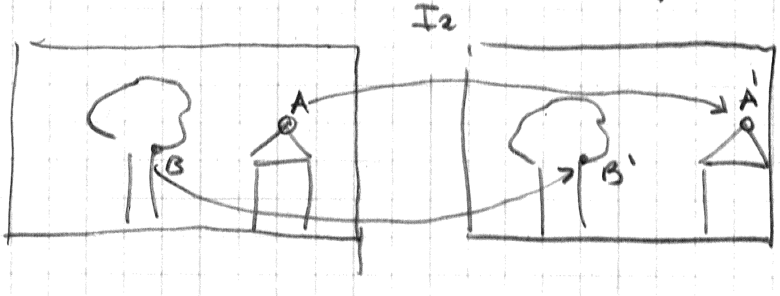
(II) MAIN OBJECTIVE AND CHALENGES

(III) SIMILARITY MEASUREMENTS BETWEEN PATCHES

↳ (IV) HARRIS

(I) USE HARRIS and SIFT. presentation to introduce the topic.

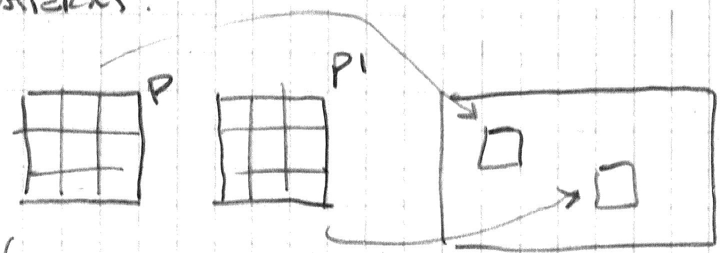
(II) Objective : (i) Detect and (ii) identify key points in pairs images.



How we AUTOMATICA[LLY] DO THIS ?

• CHALLENGES : images may have (1) DIFFERENT ILUMINATION CON[DITIONS] (2) GEOMETRICAL DEFORMATIONS (3) THE SCENE MAY BE MODIFIED OR EV[EN] NOT STATIC (4) REPEATED PATTERNS.

(III) SIMILARITY MEASURES:



(can be part of the same or diferent imges).

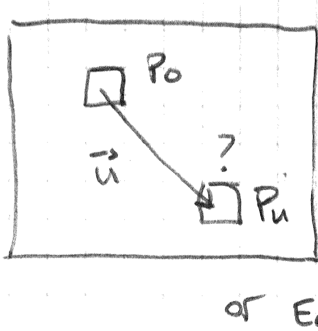
• Sum of Square difference:

$$\rightarrow E_{SSD}(P,P') = \sum_k (P(k)-P'(k))^2 \left(= \sum_{i,j} (P(i,j)-P'(i,j))^2\right)$$

• Cross Correlation:

$$\rightarrow E_{CC}(P,P') = \sum_k P(k)\cdot P'(k) ,$$

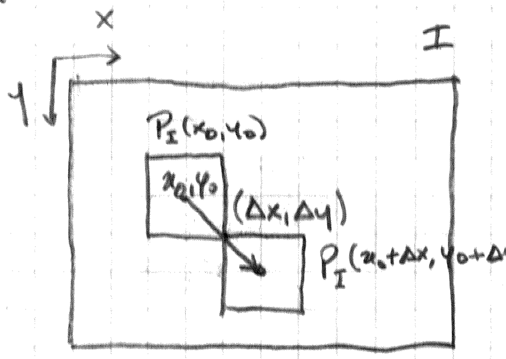
Ex:



given find such tha[t] $E_{SSD}(P_0,P_u)$ or $E_{CC}(P_0,P_u)$

(IV) HARRIS: idea analize the function

$$S_{(x_0,y_0)}(\Delta x, \Delta y) \overset{DEF}{=} E_{SSD}\left(P_I(x_0,y_0),\ P_I(x_0+\Delta x, y_0+\Delta y)\right)$$



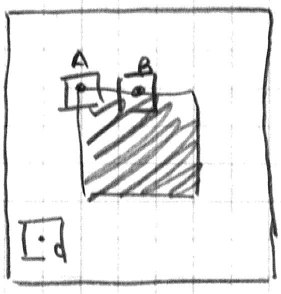
$$= \sum_{u,v}\left(I(x_0+\Delta x+u, y_0+\Delta y+v) - I(x_0+u, y_0+v)\right)^2$$

$$\approx I(x_0+u, y_0+v) + I_x(x_0+u, y_0+v)\Delta x + I_y(\ )\Delta y + O(\Delta x^2, \Delta y^2)$$

Using TAYLOR the previous approx $\approx \sum_{u,v}\left(I_x(x_0+u, y_0+v)\Delta x + I_y(x_0+u, y_0+v\right.$

$$= (\Delta x\ \ \Delta y)\begin{bmatrix}\sum_{u,v} I_x()^2 & \sum I_y I_x \\ \sum I_y I_x & \sum I_y^2\end{bmatrix}\begin{pmatrix}\Delta x \\ \Delta y\end{pmatrix} = (\Delta x, \Delta y)\, A(x_0,y_0)\begin{pmatrix}\Delta x \\ \Delta y\end{pmatrix}$$

Now analize S as a function of $(\Delta x, \Delta y)$:



What happend if we are on (A), (B) and (C)

(C) S is small $\forall(\Delta x, \Delta y)$ direction $\rightarrow$ $\underset{=(\lambda_1,\lambda_2)}{eig(A)}$ small $\lambda_1 \approx \lambda_2 \approx 0$

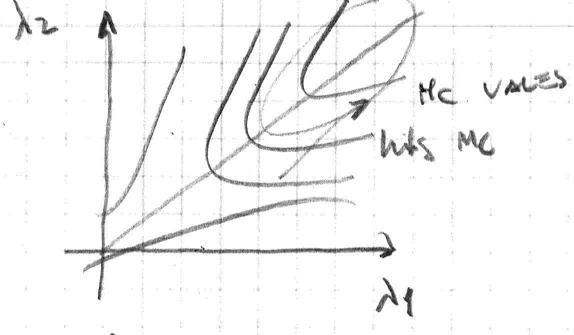
(B) S increases in one dir and is small on the other $\rightarrow$ $\lambda_1 \ll \lambda_2$

(A) S increases in two dir $\rightarrow$ λ_1 and $\lambda_2 \gg 0$.

- Trick 1:
  To be computationally more eficient. instead of computing λ_1, λ_2, we compute $M_c = \lambda_1\lambda_2 - k(\lambda_1+\lambda_2)^2 = det(A) - k\,trace(A)^2$

  sensitivity parameter

  easy and cheap to compute



$k \sim [0{,}04,\ 0{,}15]$

- Trick 2: Apply a smoothing convolution kernel before computing I_x and I_y (Differentiation is very sensitive to noise

Summarising:

- Harris implementation:

  input I, sensit. k, smooth kernel h

→ $(I_x, I_y) = \nabla I$

→ $A_{11} = I_x^2 * h$, $A_{12} = I_x I_y * h$, $A_{22} = I_y^2 * h$

→ $M_c = \underbrace{(A_{11} \cdot A_{22} - A_{12}^2)}_{\det A} - k \underbrace{(A_{11} + A_{22})^2}_{\mathrm{trace}^2(A)}$

→ set a threshold th ⇒ (x, y) is corner if $\dfrac{M_c(x,y)}{\mathrm{MAX}(M_c)} >$ th

relativ... / a abs...

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this JUST DETECT POINTS. How we compare them? ESSC / Ecc / etc