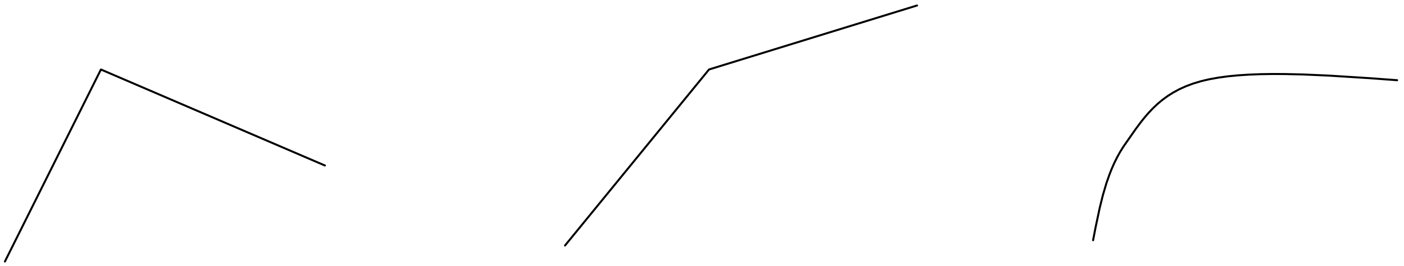
The Harris Corner Detector

- What methods have been used to find corners in images?



- How do you decide what is a corner and what is not?

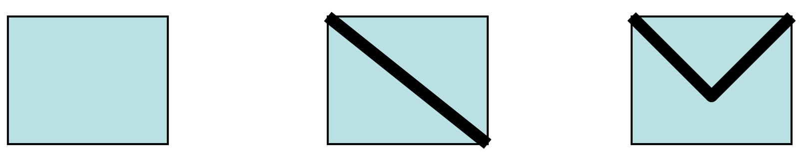
Applications

Figure 5 Results with multiple buildings in an oblique image of a complex scene complex scene

Moravec's Corner Detector

- Determine the average change of image intensity from shifting a small window.
- $E(x,y) = \sum_{u,v} w(u,v) \, | I(x+u,y+v) - I(u,v) |^2$

w is 1 within the region, And 0 outside



flat edge corner

How do we decide if there is a corner?

How does Harris improve this?

1. Use a gradient formulation to detect response at any shift (x,y).

$$E_{x,y} = \sum_{u,v} w_{u,v} \left[I_{x+u,y+v} - I_{u,v} \right]^2$$

$$= \sum_{u,v} w_{u,v} \left[xX + yY + O(x^2, y^2) \right]^2$$

approximation

where the first gradients are approximated by

$$X = I \otimes (-1, 0, 1) = \partial I / \partial x$$

$$Y = I \otimes (-1, 0, 1)^T = \partial I / \partial y$$

x-component of gradient
y-component of gradient

Hence, for small shifts, E can be written

$$E(x,y) = Ax^2 + 2Cxy + By^2$$

where

$$A = X^2 \otimes w$$
$$B = Y^2 \otimes w$$
$$C = (XY) \otimes w$$

2. Instead of 0-1 weights, use a Gaussian.

$$w(u,v) = \exp -(u^2 + v^2) / 2\sigma^2$$

3. Reformulation

$$E(x,y) = (x,y)\, M\, (x,y)^T$$

$$M = \begin{bmatrix} A & C \\ C & B \end{bmatrix}$$

4. The eigenvalues of M correspond to principal curvatures of the local autocorrelation function

• if both are small:	constant intensity
• if one is high and one is low:	edge
• if both are high:	corner

5. Putting this together

$Tr(M) = \alpha + \beta = A + B$ — Trace

$Det(M) = \alpha\beta = AB - C^2$ — Determinant

$R = Det(M) - k\, Tr(M)^2$ — Response

R is positive for corners, negative for edges, and small for flat regions.

What else?

- What do they suggest further with edges?
- What can this be used for?
- This was a 1988! What's been done in between then and now?
- Why are people starting to use it again?