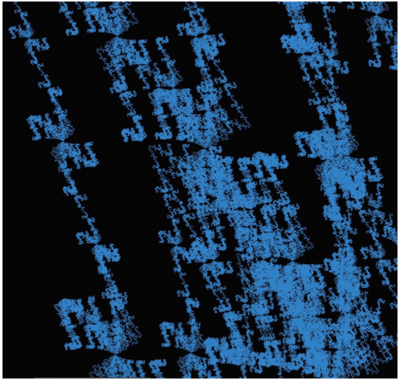
Pattern recognition

Laboratory of robotics and control systems
ITT PROJECT MANAGEMENT SERVICES L.L.C

What is a pattern?

Repetition, similarity



What is a pattern?

Repetition, similarity

Block matching

- Patch shift that minimizes difference
- Straightforward
- Non-invariant, unstable

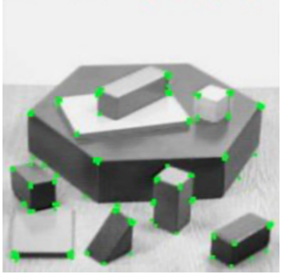
$$R(x,y) = \sum_{x',y'} (T(x',y') - I(x+x',y+y'))^2$$

Block matching

- Patch shift that minimizes difference
- Straightforward
- Non-invariant, unstable

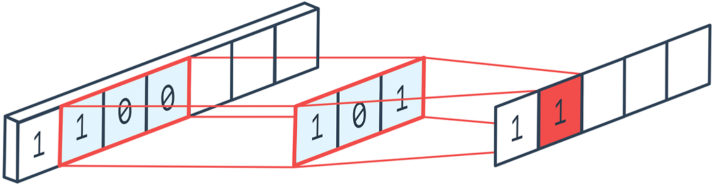
Key points

- Corners, distinct elements
- Much less in number than pixels
- Easily trackable



Convolution

The sum of the element products for all kernel positions



Smoothing filter circuit

- Kernel of unit elements
- Automatic normalization
- The element is equal to the average of neighbors

$$K = \frac{1}{25}\begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

Smoothing filter circuit

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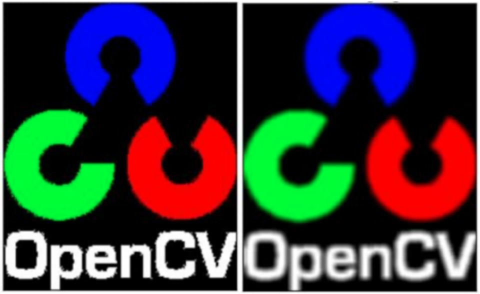


Border highlighting filters

- Discrete approximation of the derivative
- Equal to zero on a constant signal

$$G_x = \begin{bmatrix} -3 & 0 & +3 \\ -10 & 0 & +10 \\ -3 & 0 & +3 \end{bmatrix}$$

$$G_y = \begin{bmatrix} -3 & -10 & -3 \\ 0 & 0 & 0 \\ +3 & +10 & +3 \end{bmatrix}$$

Least squares method

$$y = ax + b$$

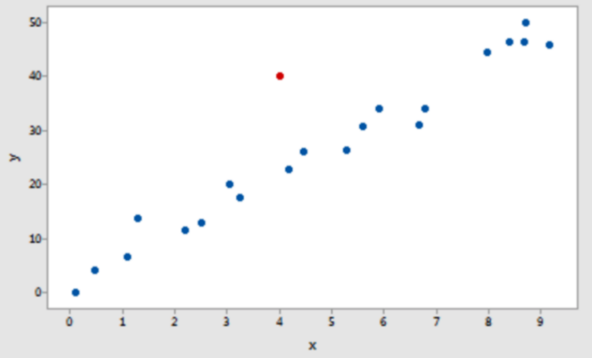
$$e_i = y_i - ax_i - b$$

$$E = \sum_{i=1}^{n} (y_i - ax_i - b)^2$$

$$\begin{cases} \dfrac{\partial E}{\partial a} = 2\displaystyle\sum_{i=1}^{n} (ax_i + b - y_i)x_i = 0 \\ \dfrac{\partial E}{\partial b} = 2\displaystyle\sum_{i=1}^{n} (ax_i + b - y_i) = 0 \end{cases}$$

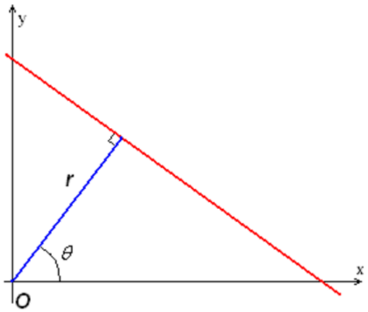
$$\hat{b} = \frac{\sum_{i=1}^{n} y_i \sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} y_i x_i \sum_{i=1}^{n} x_i}{n \sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

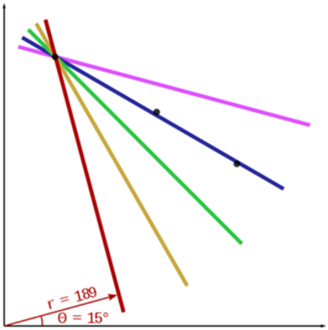
$$\hat{a} = \frac{\sum_{i=1}^{n} y_i x_i - \hat{b} \sum_{i=1}^{n} x_i}{\sum_{i=1}^{n} x_i^2}$$



Hough transform

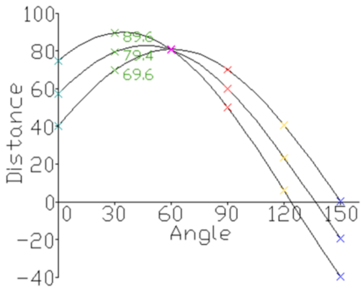
- Parameterization via angle and distance
- Finite (discrete) step

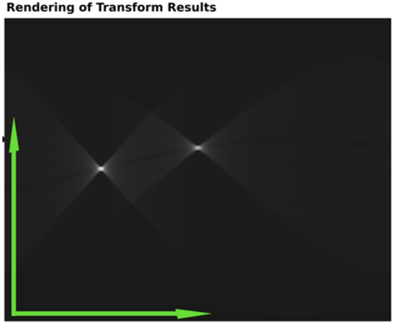




Hough transform

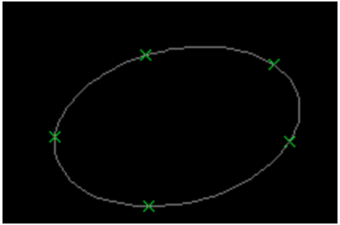
- The data point is mapped to a curve
- Result - local/global maxima





RANSAC

- Random subsample
- Model obtainment
- Quality assessment

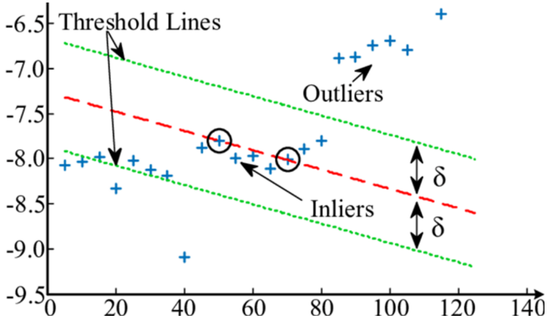


RANSAC

- Searching for a model with a maximum of inliers
- Works correctly with desired probability

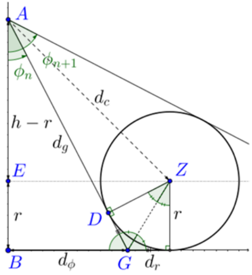
P - expected success probability
α - share of the inliers
n - number of data points
k - number of points that determine the model

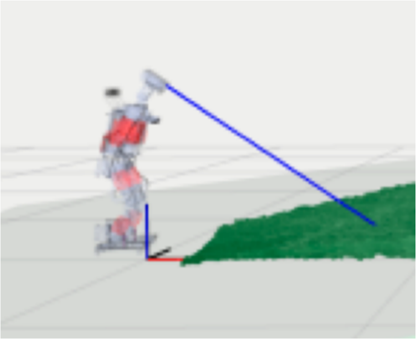
$$\alpha$$
$$\alpha^k$$
$$1-\alpha^k$$
$$(1-\alpha^k)^m = 1-P$$
$$\ln(1-\alpha^k)^m = \ln(1-P)$$
$$m\ln(1-\alpha^k) = \ln(1-P)$$
$$m = \frac{\ln 1 - P}{\ln(1-\alpha^k)}$$



TinyYOLOv3 object detection

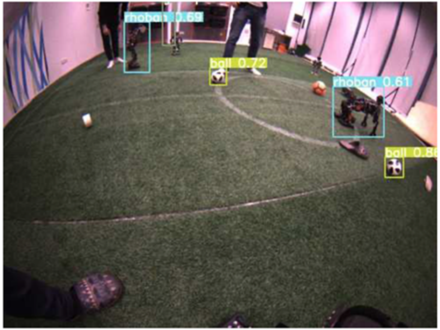
- Neural networks work well…
- … but don't get the depth on mono





TinyYOLOv3 object detection

- 1.3 times longer
- Considerably better (mAP@0.9 0.503 → 0.599)



Thank you for your time

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