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Saturday, December 7, 2024 9:47 AM

Chapter 11 : Information extraction from sensor data

→ Extract lines, circles, planes (Geometric primitives)

2 steps :

1. Segmentation (Split & Merge, RANSAC)
2. Fitting (Least squares estimation)

↓ many uses

trajectory
parameter estimation
camera calibration

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Least squares Estimation

y sensor data

x unknowns

A model you will fit

$y = Ax \Rightarrow x = A^{+}y$ A^{+} pseudo inverse (pinv)

$A \in \mathbb{R}^{m \times n}$ Assumption A is full rank

$x \in \mathbb{R}^{n \times 1}$ vector

$y \in \mathbb{R}^{m \times 1}$ vector

(1) $m = n$

A

$A^{+} = A^{-1}$

(2) $m > n$

A

$A^{+} = (A^{T}A)^{-1}A^{T}$

Least squares estimate

(3) $m < n$

A

$A^{+} = A^{T}(AA^{T})^{-1}$

Minimum norm estimate

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Example : Someone gives you some data & asks you to fit a line or curve to it.

$y = Ax$

index i	x_i	y_i
1	2	3
2	1	2
3	3	4
4	7	8
5	5	3
6	4	9

Solution : Do a scatter plot & understand the data.

✓ $y = mx + c$ (line eq.)

✓ $y = a_1 + a_2 x + a_3 x^2$ (curve eq.) $x = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix}$

$y_i = m x_i + c$

$$\Rightarrow \begin{bmatrix} 3 \\ 2 \\ 4 \\ 8 \\ 3 \\ 9 \end{bmatrix} = m \begin{bmatrix} 2 \\ 1 \\ 3 \\ 7 \\ 5 \\ 4 \end{bmatrix} + c \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

$$\Rightarrow \underbrace{\begin{bmatrix} 3 \\ 2 \\ 4 \\ 8 \\ 3 \\ 9 \end{bmatrix}}_{y} = \underbrace{\begin{bmatrix} 2 & 1 \\ 1 & 1 \\ 3 & 1 \\ 7 & 1 \\ 5 & 1 \\ 4 & 1 \end{bmatrix}}_{A_{6\times 2}} \begin{bmatrix} m \\ c \end{bmatrix} x$$

$$\Rightarrow \begin{bmatrix} m \\ c \end{bmatrix} = A^{+} y = (A^T A)^{-1} A^T y$$

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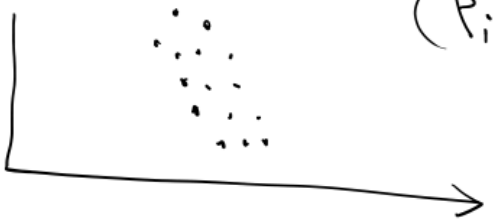
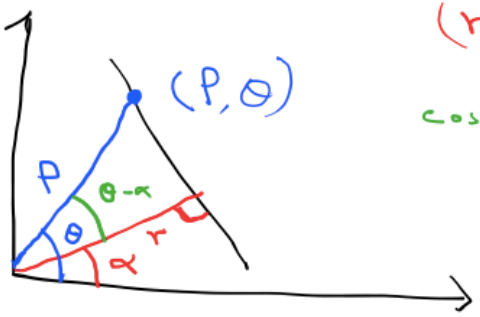
Lidar data → polar coordinates (ρ, θ)

(ρ_i, θ_i)



Line equation in polar coordinates



(r, α) line parameters

$$\cos(\theta - \alpha) = \frac{r}{\rho} = \frac{\text{base}}{\text{hyp}}$$

$$\Rightarrow \boxed{r = \rho \cos(\theta - \alpha)}$$

↑ equation of line in polar coordinates

Given (ρ_i, θ_i) $i = 1 \ldots n$

estimate (r, α)

using Least squares

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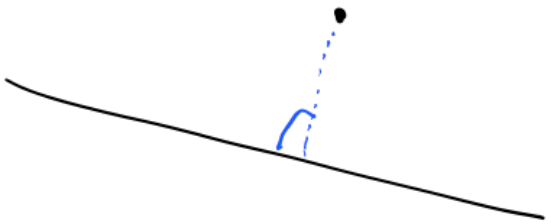
Step 1 : Line segmentation

Decide which points belong to a distinct line.

split & Merge



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