CSC 445 - Intro to Intelligent Robotics, Spring 2018

Feature Extraction

Feature Extraction

- Raw sensor information about the environment may not be directly useful to a robot.
- Feature extraction is the process of extracting information from one or more sensors into a higher level percept.
- Features are recognizable structures of elements in the environment.
  - Low-level features: geometric primitives
  - High-level features: objects
- Feature extraction can be viewed as an information reduction problem.

Considerations for Choosing Features

- Target environment
- Available sensors
- Computational power
- Environmental representation

Properties of Feature Detectors

- Repeatability
- Distinctiveness
- Localization accuracy
- Quantity of features
- Invariance
- Computational efficiency
- Robustness

Line recognition

- Line segments are one of the simplest geometric features to extract.
- Problems extracting lines in unknown environments:
  - How many lines are there?
  - Which points belong to which line?
  - Given points that belong to a line, how can the line model parameters be estimated?

Line Representation in 2D Cartesian Coordinates

- Intercept-slope

$$y = ax + b$$

- Hessian normal form

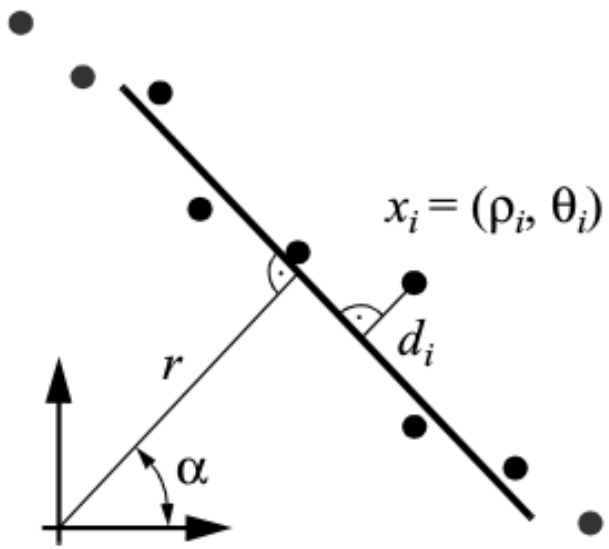
$$x \cos \alpha + y \sin \alpha - r = 0$$

Parametrizing Lines in Polar Coordinates

- A line represented in polar coordinates (ρ_i, θ_i) can be represented with the equation

$$\rho_i \cos(\theta_i - \alpha) - r = d_i$$

where r and α are the line parameters.



Fitting Models with Least Squares

- Given a set of n points, find the model parameters.
- If there is no error, all the points would lie on the model, but this is typically not true.
- Least squares finds the model parameters that minimize the sum of the squared error for each point

$$S = \sum_{i=1}^{n} \epsilon_i^2$$

where ϵ_i is the error for the i^{th} point.

Example: Least Squares Line Fitting

- Choose a line model, for example:

$$x_i \cos\alpha + y_i \sin\alpha - r = 0$$

- The sum of the squared error in this case is

$$S = \sum_{i=1}^{n} x_i \cos\alpha + y_i \sin\alpha - r$$

- The model parameters are r and α, to minimize S we need to solve the nonlinear system of equations

$$\frac{\partial S}{\partial r} = 0 \qquad \frac{\partial S}{\partial \alpha} = 0$$

Split and Merge Line Segmentation

- Split
  - Obtain a line passing by the two extreme points.
  - Find the most distant point to the line.
  - If the distance is greater than a threshold, then split and repeat with the left and right point sets.
- Merge
  - If two consecutive segments are close/collinear enough, then obtain the common line and find the most distant point.
  - If the distance is less than or equal to a threshold, then merge both segments.

Split and Merge Line Segmentation