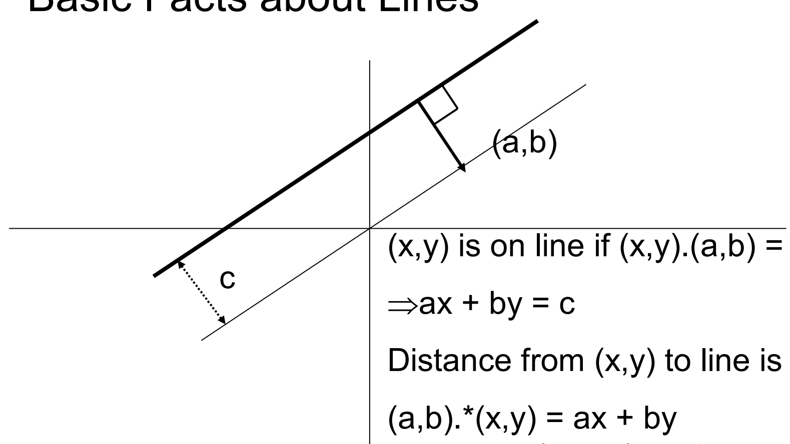
RANSAC

- = Random Sample Consensus
  - Hypothesize and test.
- Used for Parametric Matching
  - Want to match two things.
  - Hypothesized match can be described by parameters (eg., translation, affine….)
- Match enough features to determine a hypothesis. See if it is good. Repeat.

Parametric Grouping: Grouping Points into Lines

Basic Facts about Lines



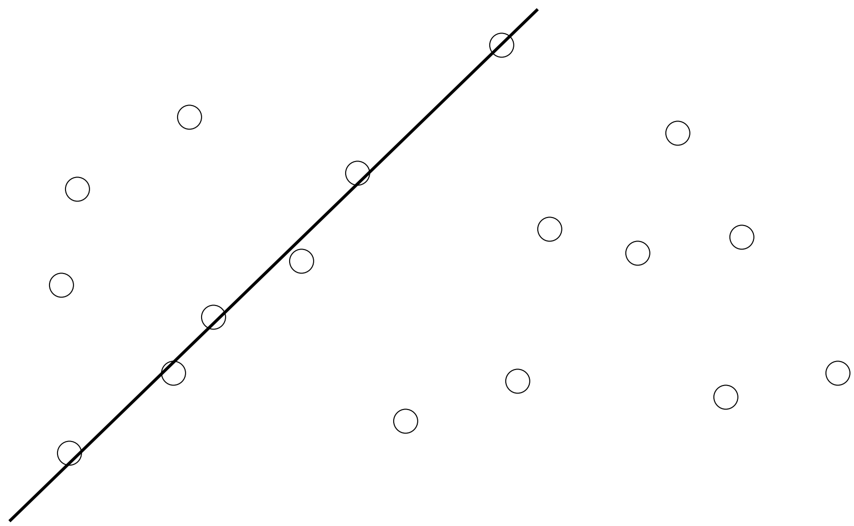
(x,y) is on line if (x,y).(a,b) = c

$\Rightarrow$ax + by = c

Distance from (x,y) to line is

(a,b).*(x,y) = ax + by
provided a*a + b*b = 1

Line Grouping Problem



This is difficult because of:

- Extraneous data: Clutter
- Missing data
- Noise

Precise Definition?

- Find a line that is close to as many points as possible.
  - Close could mean within ε pixels.
- Find k lines so that every point is close to one of them.
  - Close could mean with ε pixels.
  - Or, could mimimize sum of squares distance from each point to nearest line.

Brute Force Approach

- Try every possibility
  - Every line (infinite)
  - Fit a line to every subset of points (exponential).
- Discrete sampling
  - Could sample slope and offset uniformly.
  - Sample random lines
  - Random lines likely to be good.

RANSAC: Random Sample Consensus

- Generate Lines using Pairs of Points

How many samples?

Suppose *p* is fraction of points from line.

n points needed to define hypothesis (2 for lines)

k samples chosen.

Probability one sample correct is:

$$1-(1-p^{n})^{k}$$

RANSAC for Lines: Continued

- Decide how good a line is:
  - Count number of points within ε of line.
    - Parameter ε measures the amount of noise expected.
  - Other possibilities. For example, for these points, also look at how far they are.
- Pick the best line.

Algorithm 15.4: RANSAC: fitting lines using random sample consensus

Determine:
    n — the smallest number of points required
    k — the number of iterations required
    t — the threshold used to identify a point that fits well
    d — the number of nearby points required
        to assert a model fits well
Until k iterations have occurred
    Draw a sample of n points from the data
        uniformly and at random
    Fit to that set of n points
    For each data point outside the sample
        Test the distance from the point to the line
            against t; if the distance from the point to the line
            is less than t, the point is close
    end
    If there are d or more points close to the line
        then there is a good fit. Refit the line using all
        these points.
end
Use the best fit from this collection, using the
    fitting error as a criterion

(Forsyth & Ponce)

RANSAC for Image Matching

Image Matching

- Detect features in each image (eg., use blob detection).
- Randomly select enough matches to determine a transformation that will align the images.
  - Eg., if we use an affine transformation, we need 3 matching points. Pick three random points in image one, and match each to a random point in image 2. O(n^6) possible matches.
- Apply this transformation to all points in image 1.
- Count number of points that are transformed "near" (say within 2 pixels) of a point in image 2.
- Pick transformation that matches the most points.

Improvements

- Problem: O(n^6) matches is a lot. Only one in O(n^3) will be right.
- Solution: for each point in image 1, use SIFT descriptors to find point in image 2 that provides best match.
- If most of these matches are correct, we now have much higher chance of finding good matches, with a small chance that we miss some.