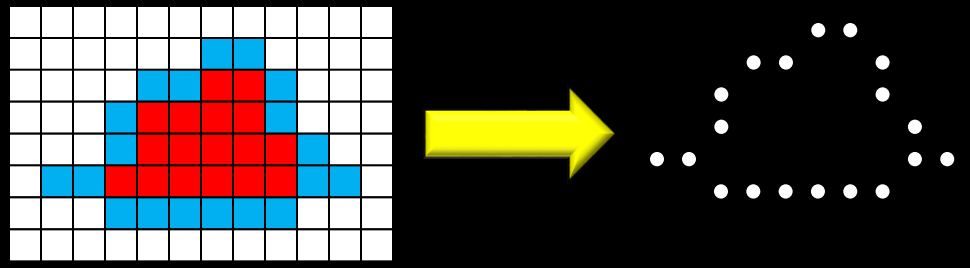
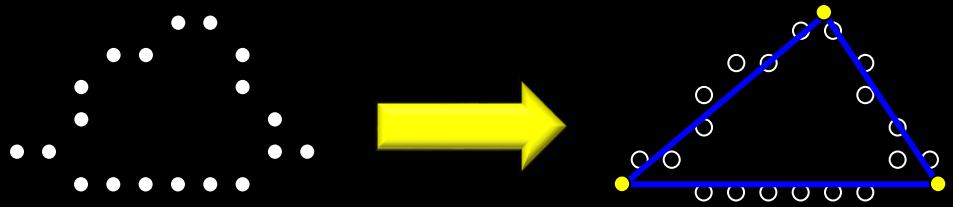
Converting to Vector Maps

Converting To Vector

- Once we have detected object borders within the occupancy grid, we can convert to polygons.
  - Consider each obstacle separately.
  - When tracing a border, build up a list of the border points for that obstacle in sequential order … assume each grid cell is a point.
  - Then run a line-fitting algorithm





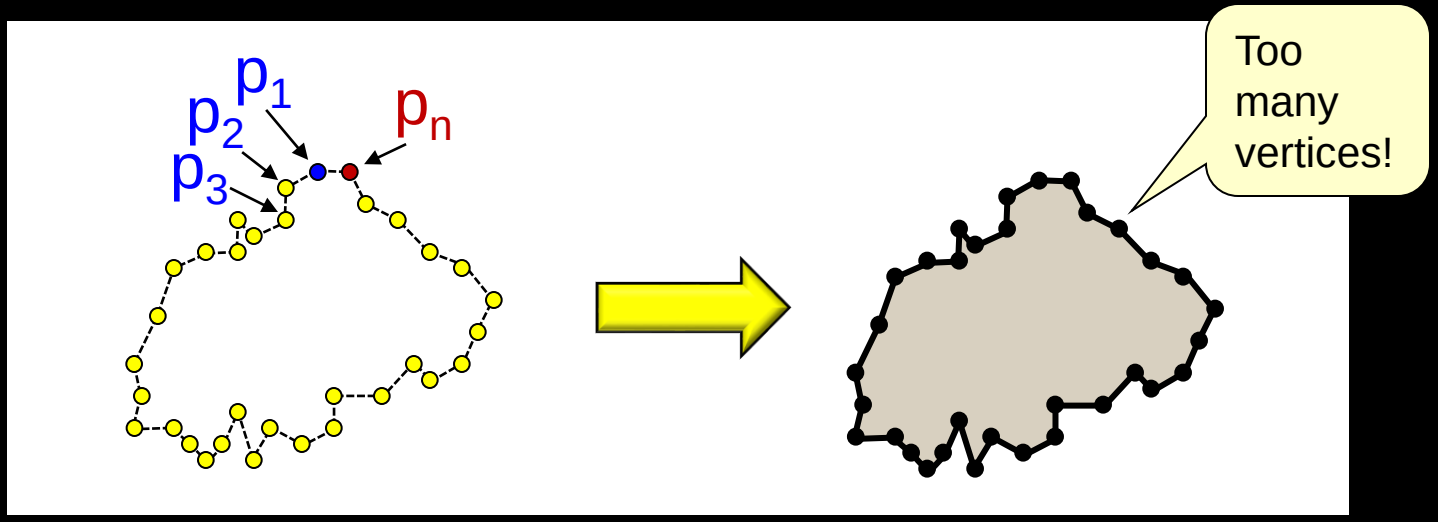
Converting To Vector

- Key issues:
  - How do we group points into line segments ?
  - How can we detect and eliminate noisy data ?
- There are a variety of common techniques:
  - Split & Merge
  - Incremental
  - Line Regression
  - RANSAC (Random Sample Consensus)
  - Hough-Transform
  - EM (Expectation-Maximization)

Simplest and popular … we will use this one.

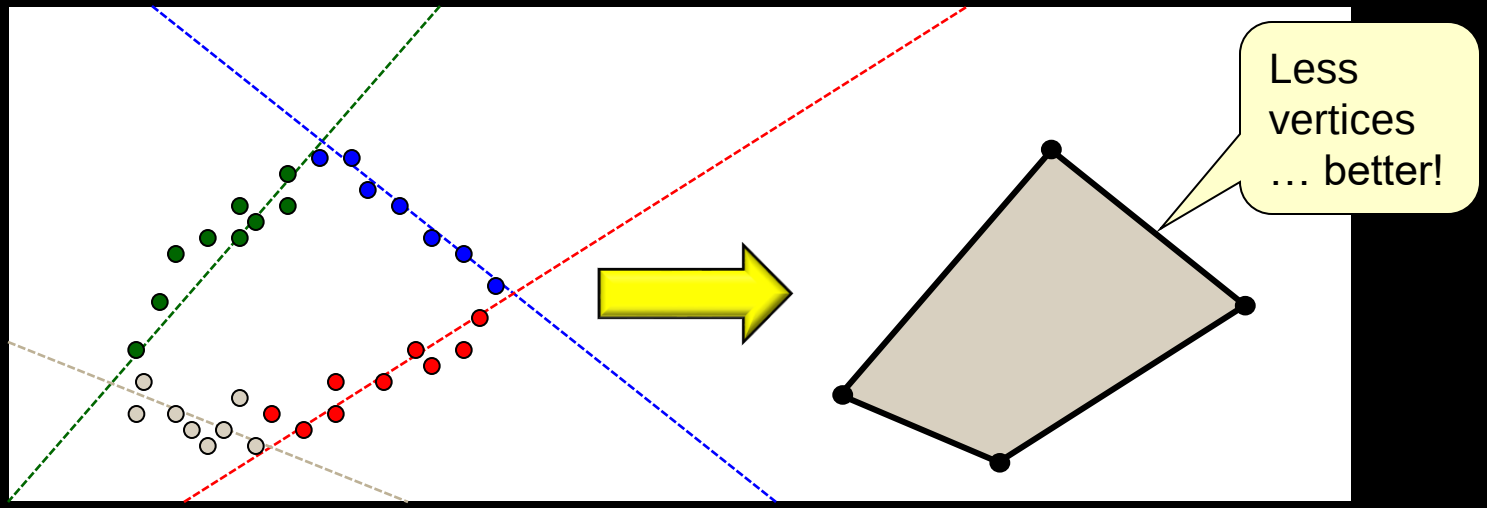
The Main Idea

- Consider a set of border points:
  - $P = \{p_1, p_2, p_3, \ldots, p_n\}$ where $p_i = (x_i, y_i)$, $1 \leq i \leq n$
  - As we do a border-tracing algorithm, these points will be coming in a counter-clockwise order
- We can simply connect all points in order, but this is too many points and assumes that all points are valid.



The Main Idea

- It is better to try and “fit” lines to the data:



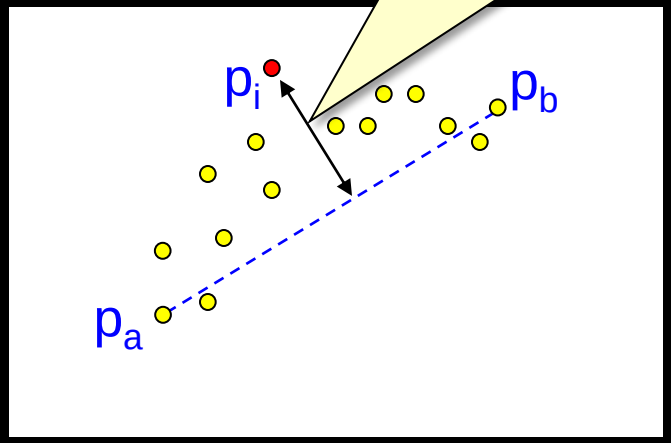
- But how do we know which points fit to a line ?
  - Assume consecutive points lie on the same line unless they are too far away from the line.

The Main Idea

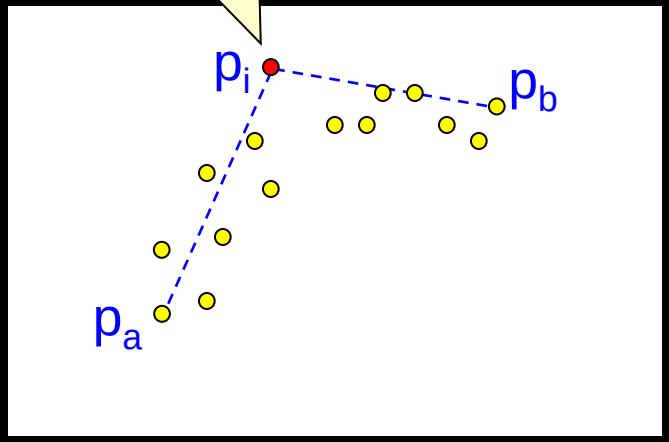
- Let p_i be point of maximum distance from line L = $\overline{p_a p_b}$

Distance from $\mathbf{p_i}$ to **L** is:

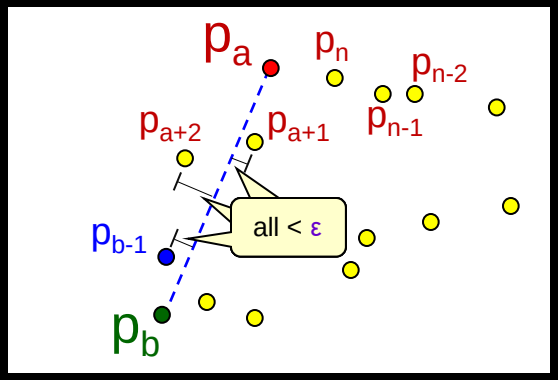
$$\frac{|(x_b-x_a)(y_a-y_i)-(x_a-x_i)(y_b-y_a)|}{\sqrt{(x_b-x_a)^2+(y_b-y_a)^2}}$$

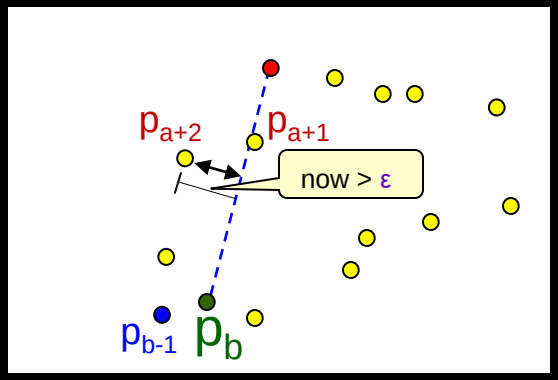


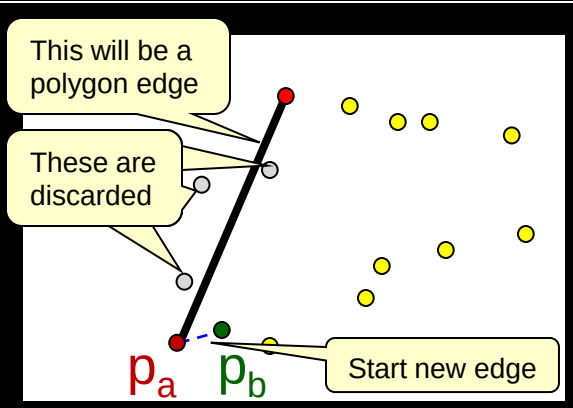
If $\mathbf{p_i}$ is too far away, then this data must represent more than one line (i.e., two distinct polygon edges).

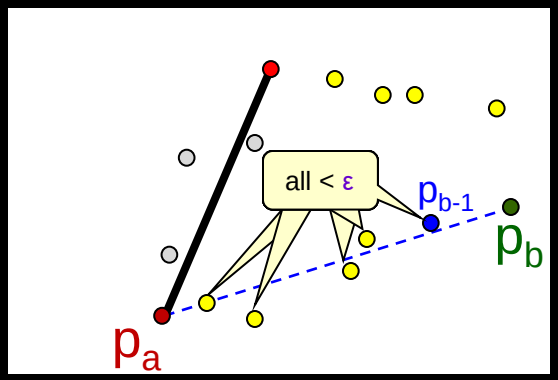


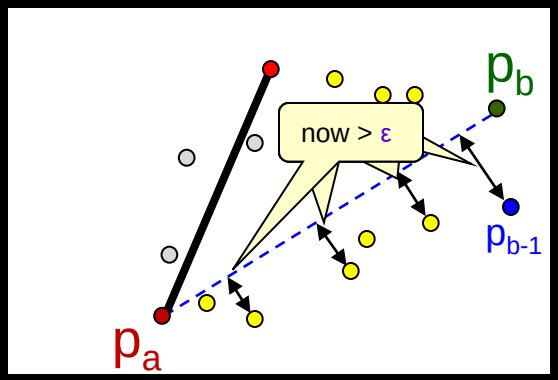
The Incremental Algorithm

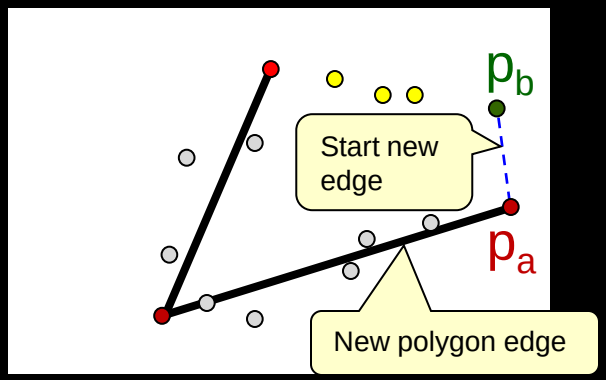


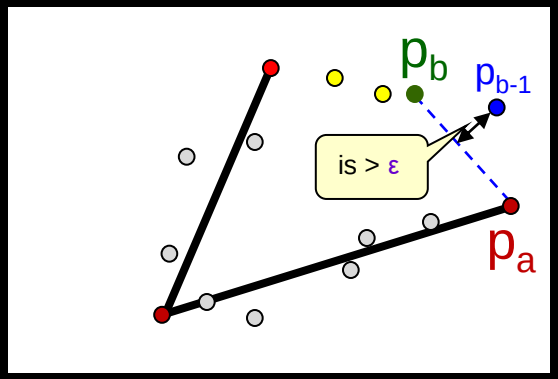


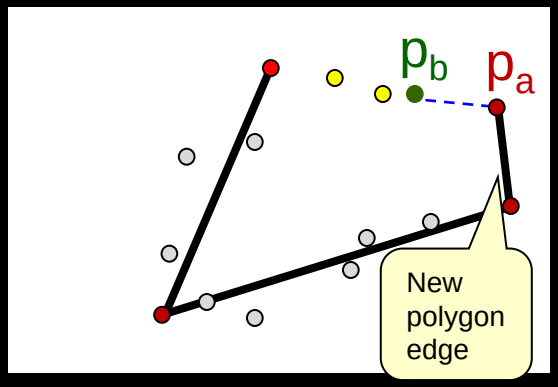


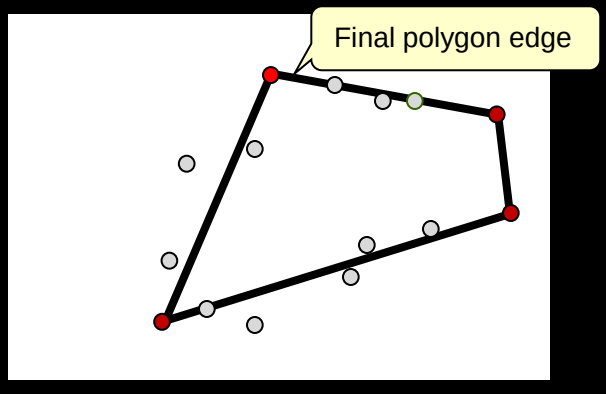












The Pseudocode

- Here is the algorithm for point set p_1, p_2, p_3, …, p_n:

1. Set **polygon** to be a new obstacle with no vertices
2. First, make sure the point set has at least 3 points, otherwise quit
3. Set **a** = **1**, and set p_a to be the **polygon**'s first vertex
4. **FOR** index **b** = **2** to **n** **DO {**
5. **FOR** index **i** = **a+1** to **b-1** **DO {**
6. **IF** point p_i is too far from line $p_a p_b$ **THEN {**
7. Add p_{b-1} as the next vertex of the **polygon** unless it is the same as the last vertex added.
8. Set **a** = **b-1**.
9. **}**
10. **}**
11. **}**

Note that the pseudocode has points with indices **1** to **n** but our **Obstacle** indices go from **0** to **n-1**.

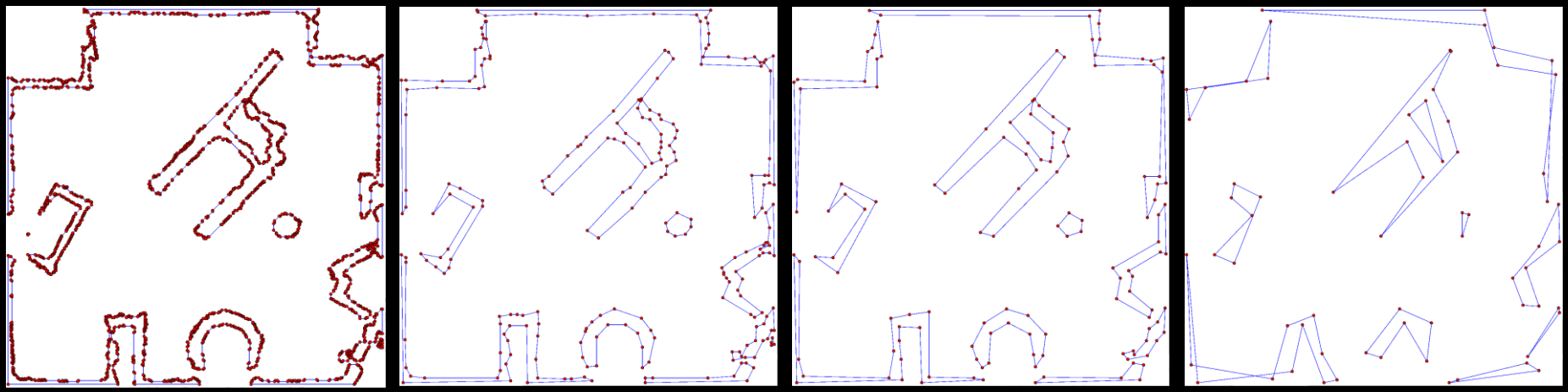
Too far means greater than some LINE_TOLERANCE (i.e., denoted as ε in the previous slide)

Since variable **a** has been changed, p_a must also be updated.

- Once the polygon is created, we should check to make sure it has at least three vertices. If not, we discard it since it is not a proper polygon.

The Incremental Algorithm

- By increasing the line-fit tolerance, the number of polygon vertices decreases:



Increased Line-Fit Tolerance (i.e., Error Threshold)

Start the Lab …