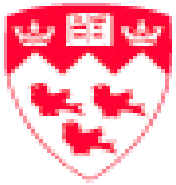


CS-417 INTRODUCTION TO ROBOTICS AND INTELLIGENT SYSTEMS

Multi-Robot Systems

Ioannis Rekleitis

Auctions!

- Used to improved performance
- A central coordinator or one team member call/administer the auction
- Robots bid for tasks based on some estimated reward/cost

Classification

- Team size
- Communication range
- Communication topology
- Communication bandwidth
- Processing ability
- Team Reconfigurability
- Team Composition

Marsupial Robots

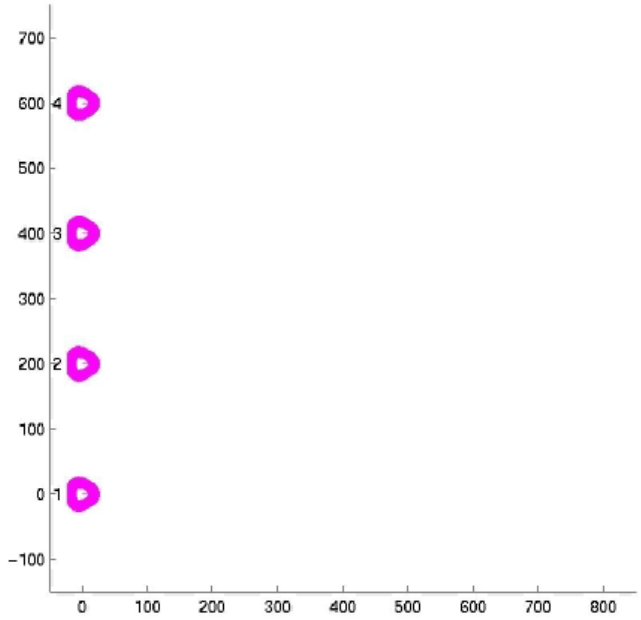
Also watch: http://www.youtube.com/watch?v=hCGgoPS91Rw

From: http://www.nosc.mil/robots/resources/marsupial/marsupial.html

Marsupial Robots

- From: http://distrob.cs.umn.edu/demos.php

Formations


700
600
500
400
300
200
100
0
−100
4
3
2
1
0
100
200
300
400
500
600
700
800


35
69
64
66
68
70
SRI

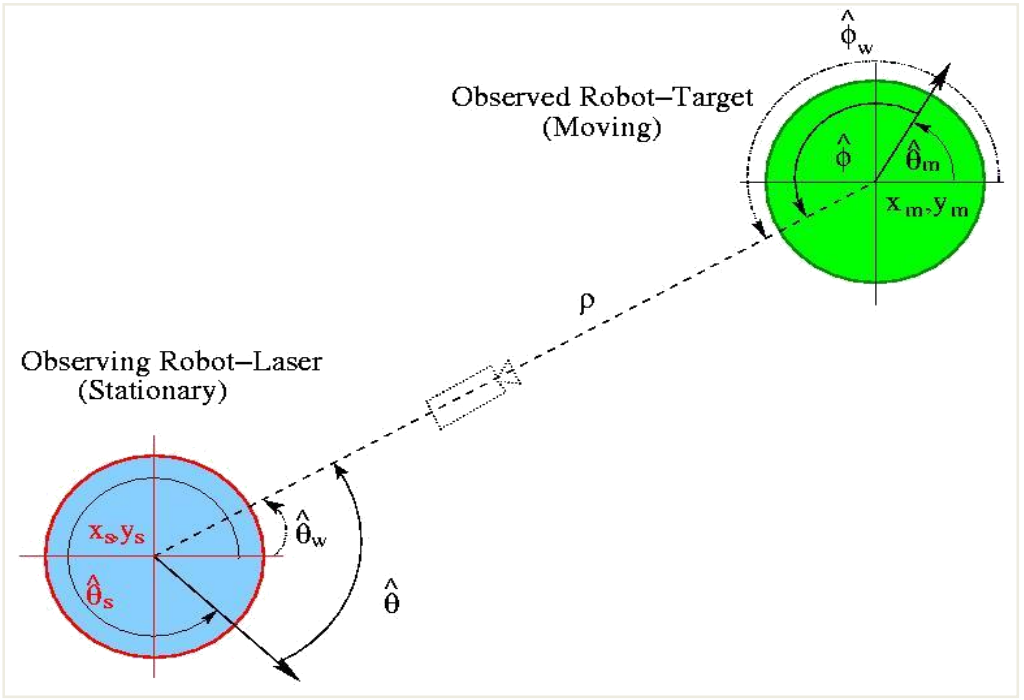
Formations

- Follow the leader
- Unit Center
- Maintain position
- Avoid Obstacles

Cooperative Localization, Mapping, and Exploration

Cooperative Localization

- Pose of the moving robot is estimated relative to the pose of the stationary robot. Stationary Robot observes the Moving Robot.



Robot Tracker Returns:

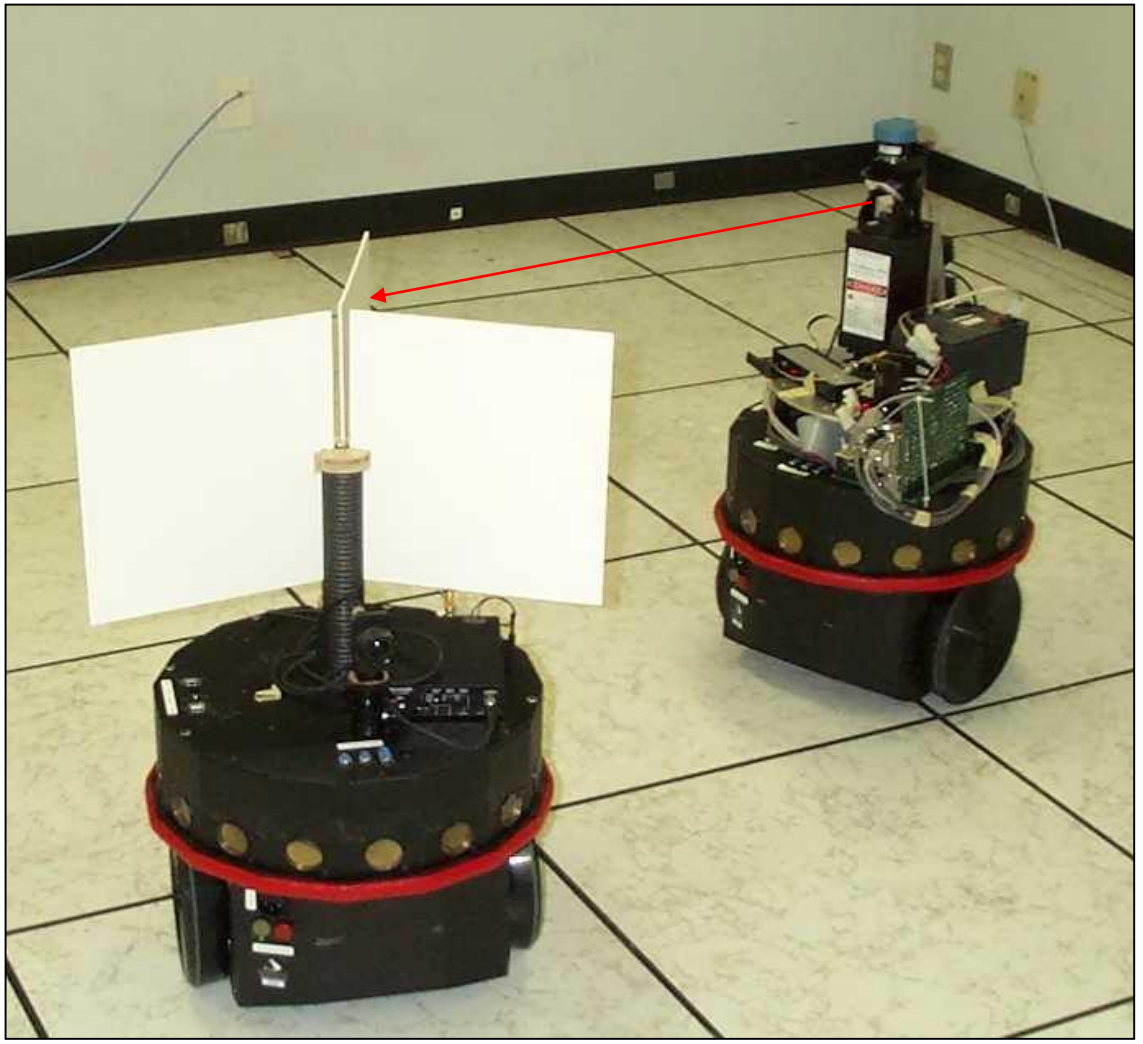
<ρ,θ,ϕ>

$$\mathbf{x}_{m_{est}}(k+1) = \begin{pmatrix} x_{m_{est}} \\ y_{m_{est}} \\ \theta_{m_{est}} \end{pmatrix} = \begin{pmatrix} x_s + \rho\cos(\theta+\theta_s) \\ y_s + \rho\sin(\theta+\theta_s) \\ \pi - (\phi - (\theta+\theta_s)) \end{pmatrix}$$

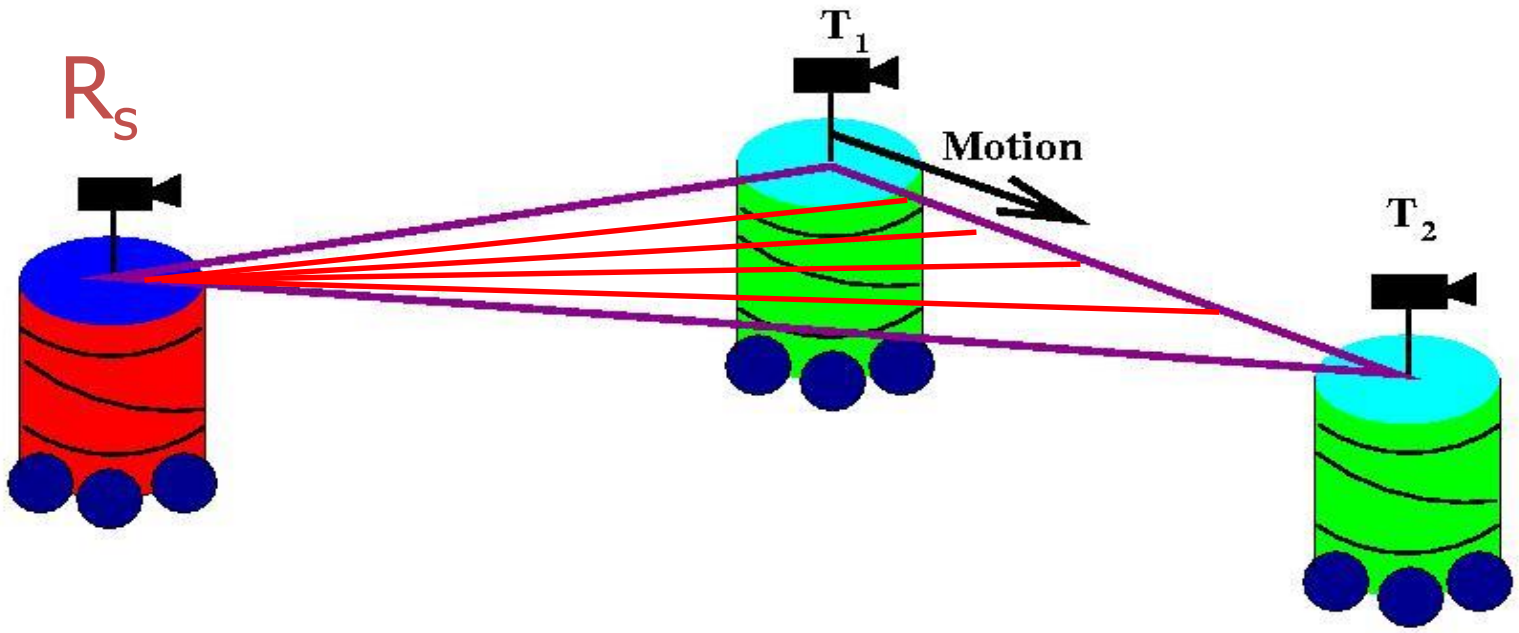
Laser Robot Tracker

Robot Tracker Returns:

$<\rho,\theta,\phi>$



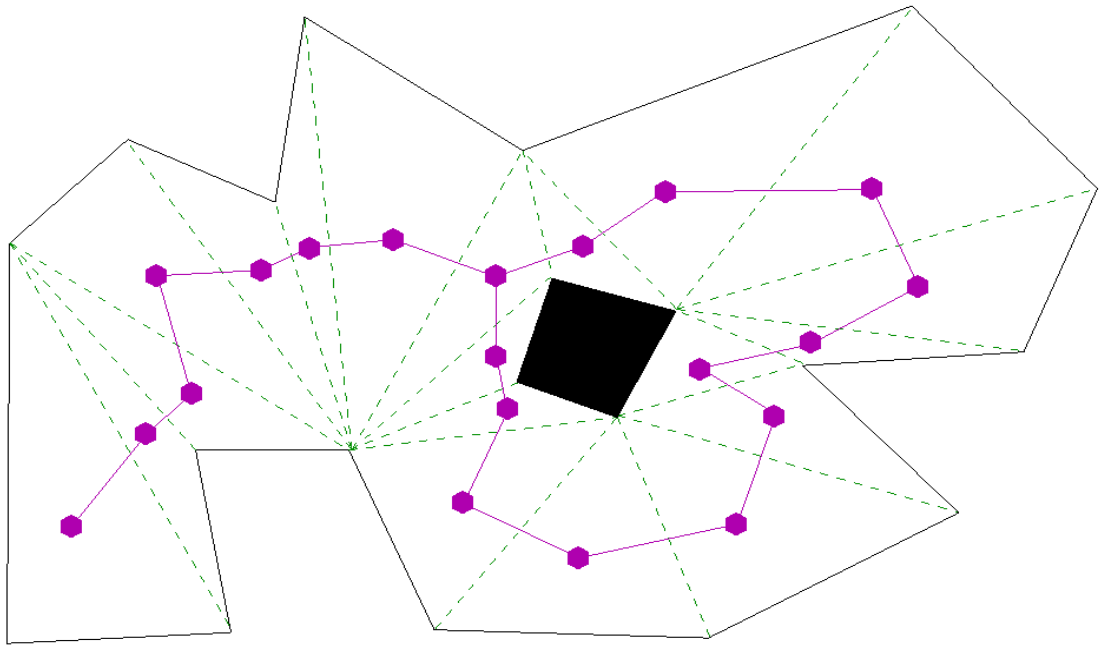
Exploration and Mapping
(Triangulation)



- If the line of visual contact is not interrupted during the motion, then the triangle $[R_S, T_1, T_2]$ is free space.
- Connect the triangles of free space in order to construct a map of the environment.

Triangulation Algorithm: Main Ideas

- **Bounded Area:** The range of the tracker sensor is larger than any diagonal of the environment

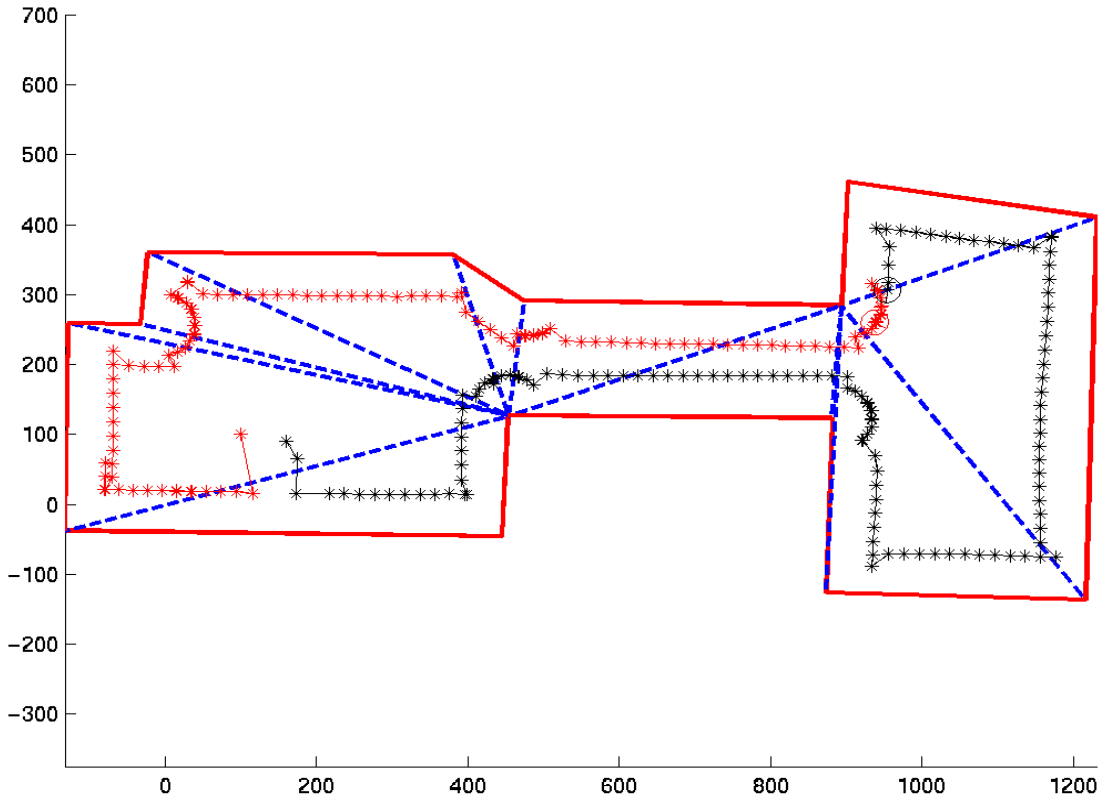


Triangulation Algorithm: Main Ideas

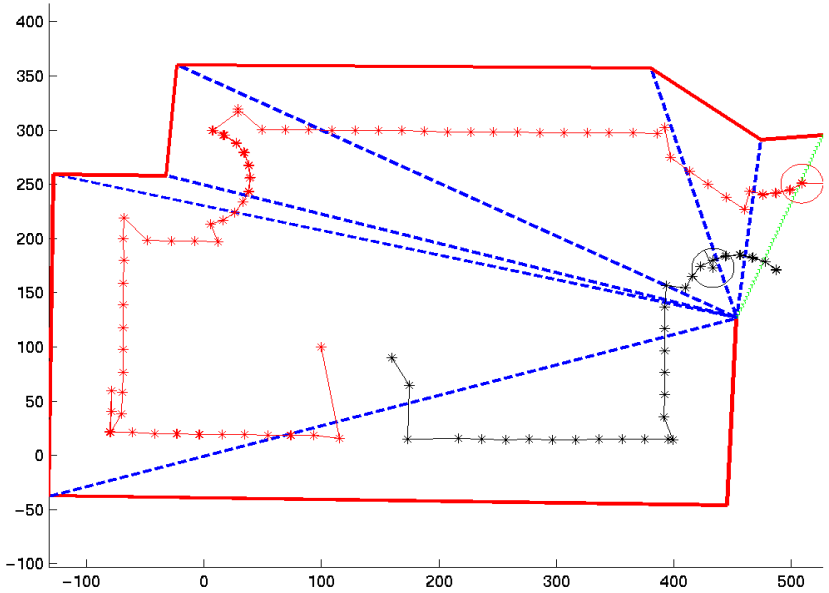
- **Robot Position:**
  - Stationary Robot: Positioned at the corners of the environment (vertices of the polygon).
  - Moving Robot: Follows the walls.
- **Exploration order:** The two robots explore the free space by following the Dual Graph of the Triangulation.
- **Decision points:** Reflex vertices.

Cooperative Exploration

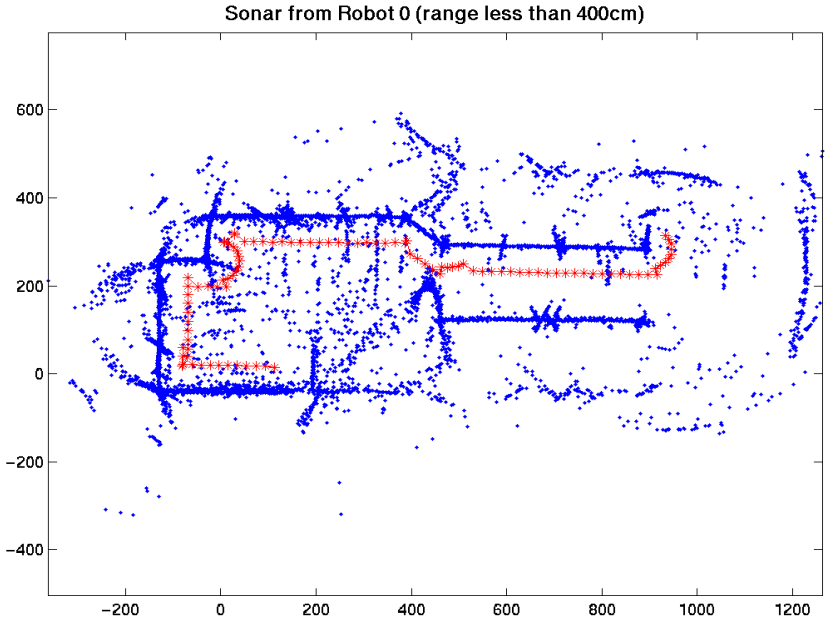
Experimental Results (Triangulation)

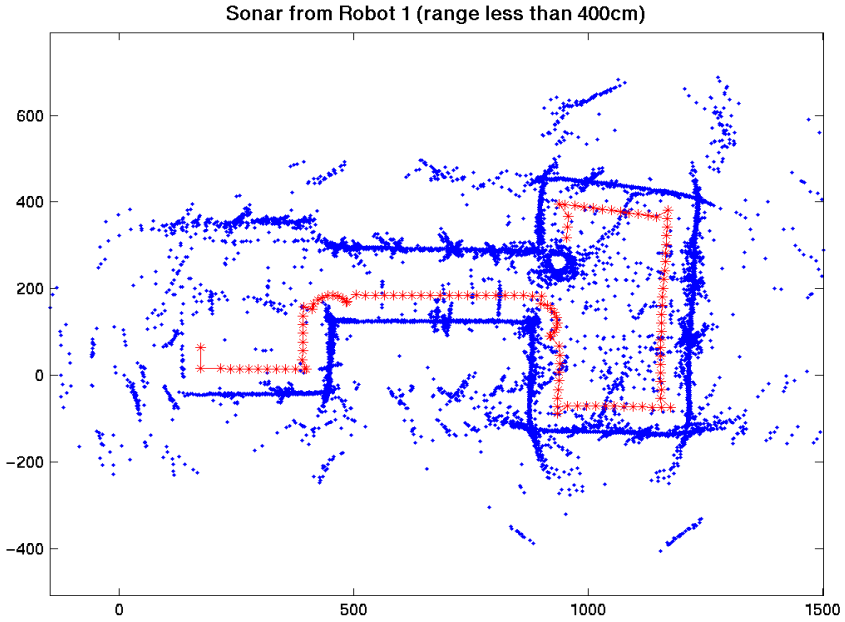


Moving out

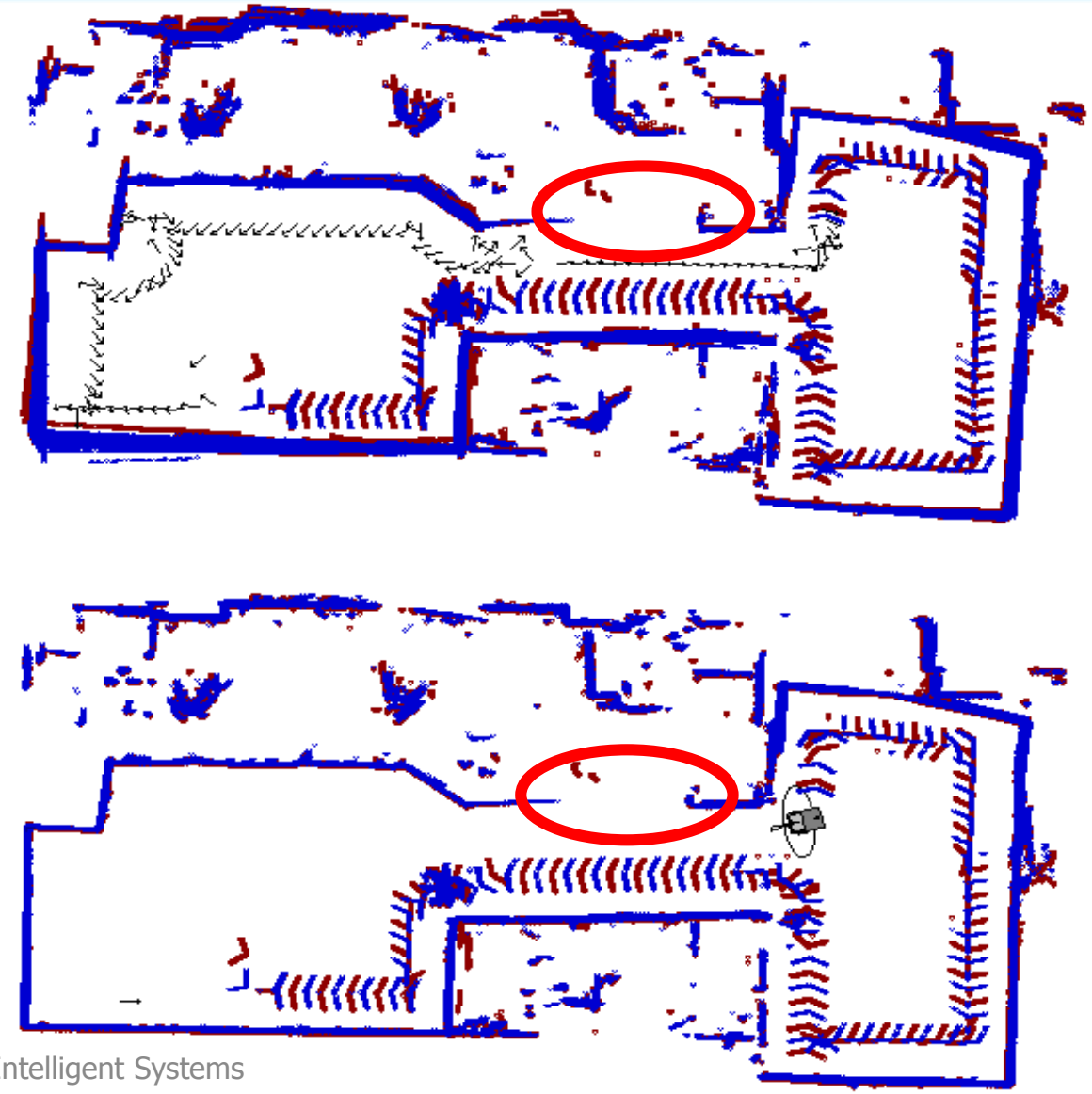


2 Laboratories, Sonar Data



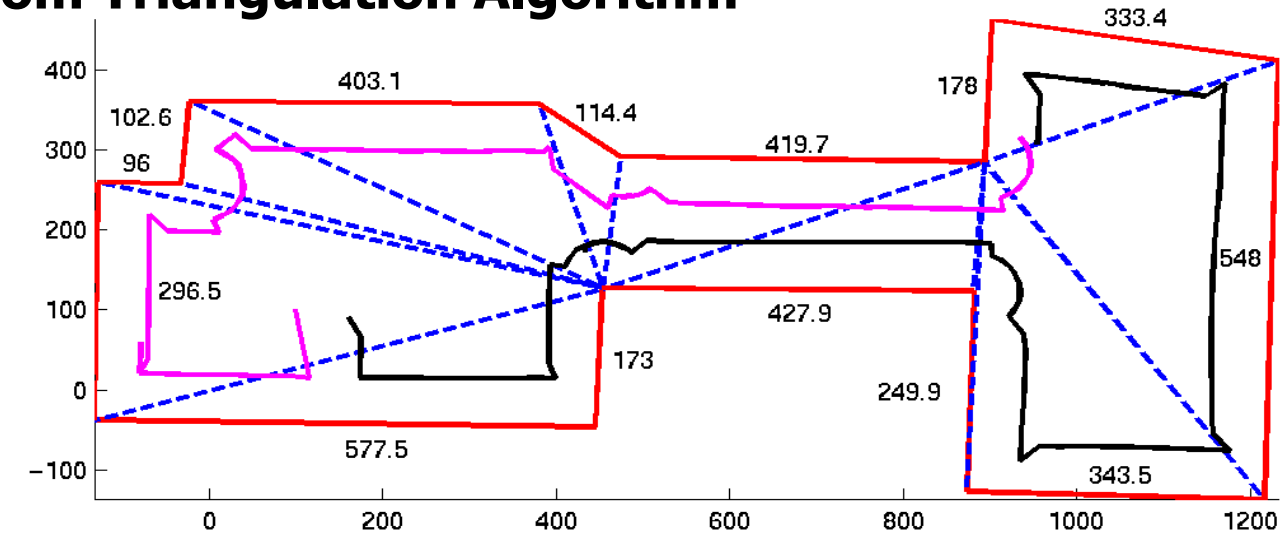


2 Laboratories, Laser Data



Map from Scan Match (S. Gutmann)

Sonar Map from Triangulation Algorithm



Perimeter: 42.71m. Mean error: 0.046m