Conflict Resolution Using α-shapes for Distributed Robotic Sampling of Ambient Phenomena in Initially Unknown Environments

Brad Woosley

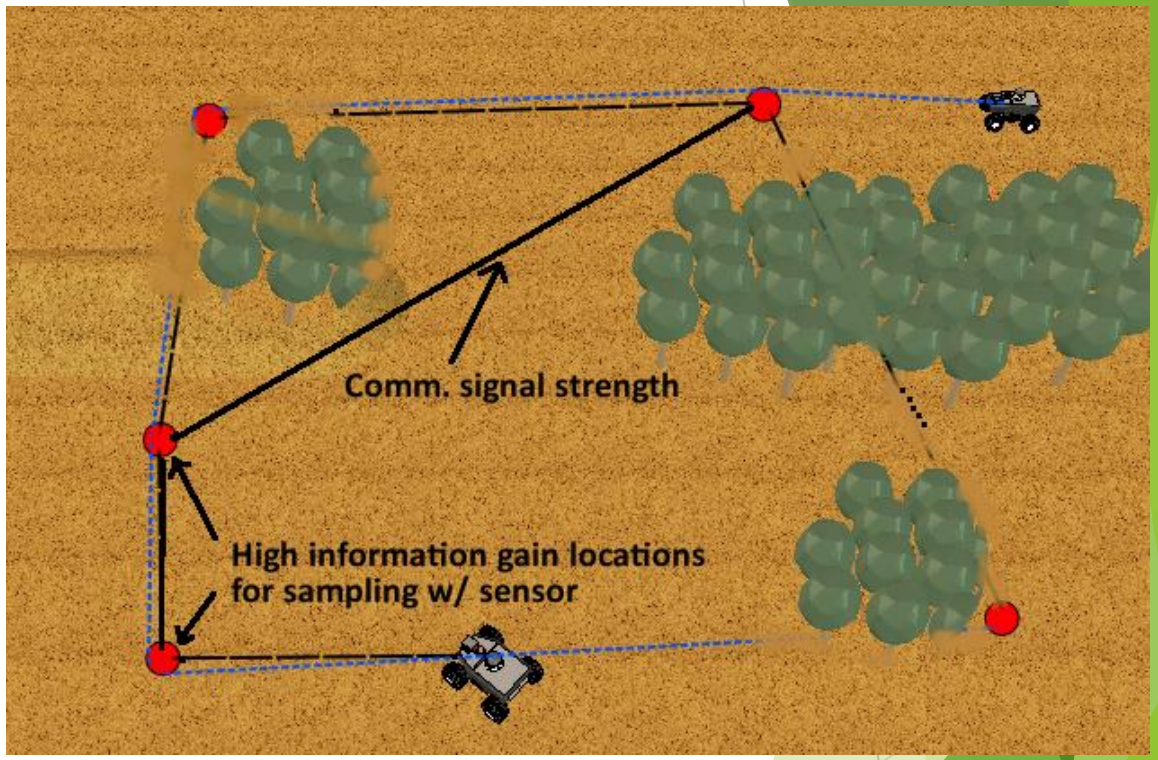
Doctoral Candidate

Advisor: Dr. Raj Dasgupta

Presented at: 2019 Computer Science Graduate Research Workshop

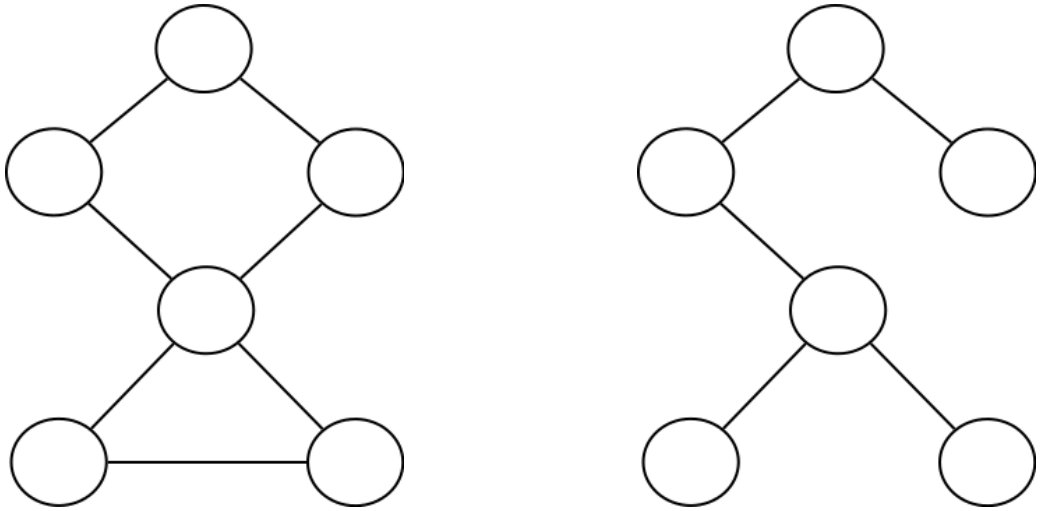
Introduction

- Exploration of environment
- Limited communications range
- Each robot generates its next sampling (goal) location
- Goals are not selected from a predefined set
- Two robots visiting same location in quick succession unlikely to be useful
- Need way to deconflict selected goal locations
- Exploration portion previously handled
  - B. Woosley, P. Dasgupta, J.G. Rogers, J. Twigg "Multi-robot Information Driven Path Planning under Communications Constraints" Autonomous Robots (Under Review)



Proposed approach

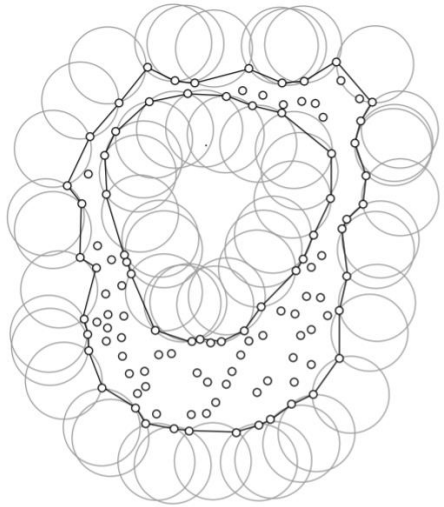
- Robots are connected together in a communications graph
- Can generate a communications tree from the graph
- Cache goal locations inside the communications tree



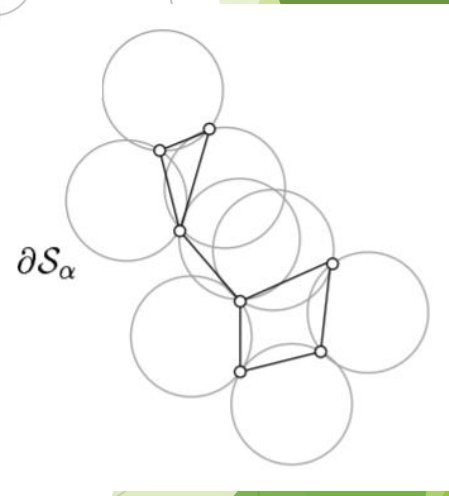
Determine caching locations

- Robots near a proposed goal location should know of robots heading to that region
- Select a root node of communications tree
  - Base station node
  - Robot closest to base station
- Assign to each robot a region of the environment
  - Region of environment it's children is in
  - Build using Alpha Shapes

Alpha Shapes



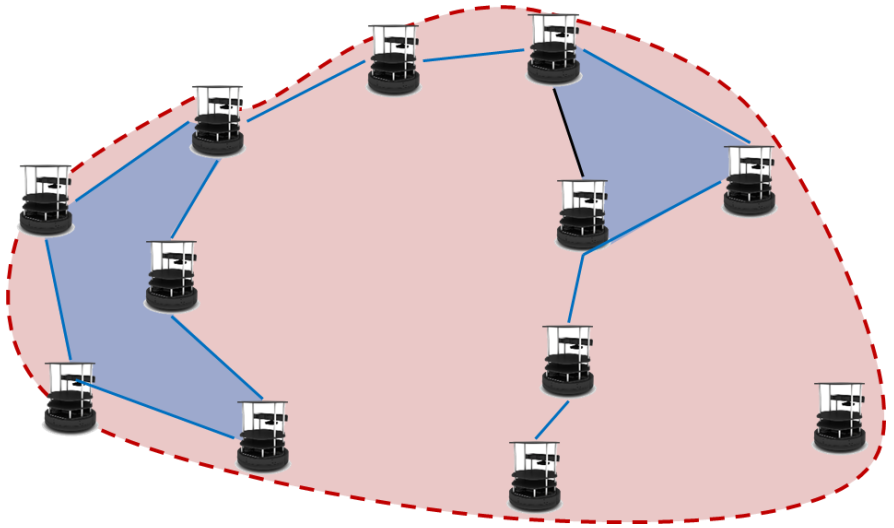
- Concept from computational geometry
- Have a set of points in a 2D plane
- Generate a polygon around the points
- Start with entire plane in the polygon
- Remove circular regions of size alpha with no points in it
- Convert the curves of remaining shape to straight edges



Edelsbrunner, Herbert; Kirkpatrick, David G.; Seidel, Raimund (1983), "On the shape of a set of points in the plane", *IEEE Transactions on Information Theory*, **29**(4): 551–559, doi:10.1109/TIT.1983.1056714

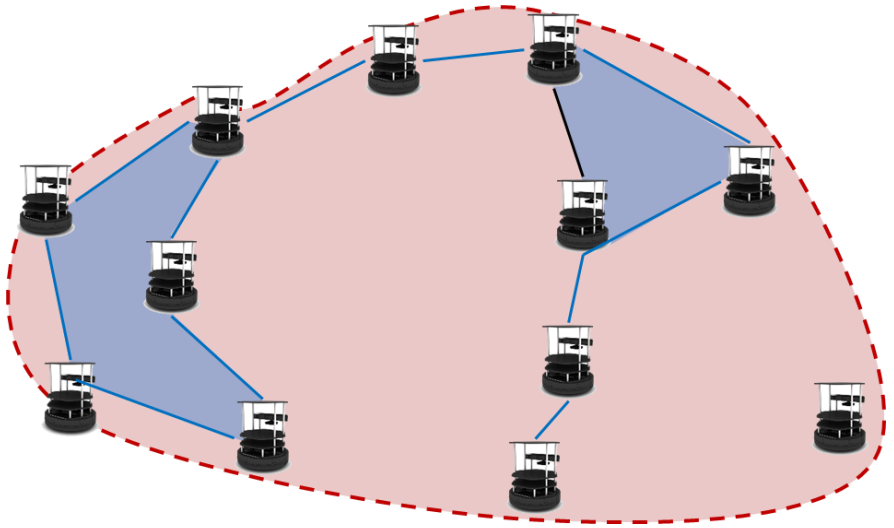
Comparison to Convex Hulls

- Convex hull creates a convex polygon around the points (pink)
- Covers a large area
- Alpha shapes (blue) provide a smaller concentrated area to focus on



Query for conflict

- If query point is inside alpha shape
  - This robot or it's children may know of conflict
  - Cache point as potential conflict point in memory
  - Send query point to all children
- If query point is outside alpha shape
  - A robot reachable through parent node may know of conflict
  - Send query point to parent
- If conflict is found, send conflict report back to original robot



Experimental Verification

- H1: Use of alpha shapes has less overlap than other shape generation approaches
  - Compare Alpha Shapes to Convex Hulls
- H2: Approach resolves conflicts using fewer communications than network flood approach
  - Compare tree caching to network flooding

Conclusions and Future Works

- Proposed approach to resolve conflicts in selected goal locations
- Will be evaluated in simulations
- Plan to extend approach to provide theoretical guarantees
  - Time bounds on finding conflicts

Acknowledgements

- NASA
  - Space Grant
  - EPSCOR
- Army Research Labs
- UNO GRACA Grant

- E-mail: bwoosley@unomaha.edu