Decentralized Cooperative Trajectory Estimation for Autonomous Underwater Vehicles

Liam Paull\textsuperscript{1,2}, Mae Seto\textsuperscript{2,3} and John Leonard\textsuperscript{1}

\textsuperscript{1}MIT CSAIL, \textsuperscript{2}University of New Brunswick, \textsuperscript{3}Defense R&D Canada
Challenges and Potential Benefits

Challenges:
• High latency
• Low bandwidth
• Unacknowledged (broadcast)
• Unreliable
Challenges and Potential Benefits

Challenges:
• High latency
• Low bandwidth
• Unacknowledged (broadcast)
• Unreliable

Potential Benefits:
• Vehicles surface for GPS fix less frequently
• Collected data more accurately localized through trajectory smoothing
Underwater Cooperative Localization
Underwater Cooperative Localization
Underwater Cooperative Localization
Underwater Cooperative Localization
Underwater Cooperative Localization
Underwater Cooperative Localization
Underwater Cooperative Localization
Centralized Multi-AUV Pose Graph
Centralized Multi-AUV Pose Graph

GPS measurements
Centralized Multi-AUV Pose Graph

Compass measurements
Centralized Multi-AUV Pose Graph

DVL derived odometry
Centralized Multi-AUV Pose Graph

Inter-vehicle range measurements
Centralized Multi-AUV Pose Graph

Problem: Too much data to send through Acomms
Decentralized Multi-AUV Pose Graph

New factor connects other vehicle nodes at times of contact
Advantages of Proposed Approach

• Guaranteed connectedness of pose graph

• Data throughput scales linearly with team size

• Data throughput constant with time

• No requirements on team hierarchy
2 AUVS, One Surfacing for GPS
Different Packet Loss Rates

\[ \sigma^2_{x_t} + \sigma^2_{y_t} \]

- 100% Failure
- 80% Failure
- 50% Failure
- 20% Failure
- 0% Failure

time(s)

0 100 200 300 400 500

0 20 40 60 80 100 120