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Autonomous Mobile Robot Exploration with an Information-Gain Metric

S&T Campaign: Information Sciences
System Intelligence and Intelligent Systems

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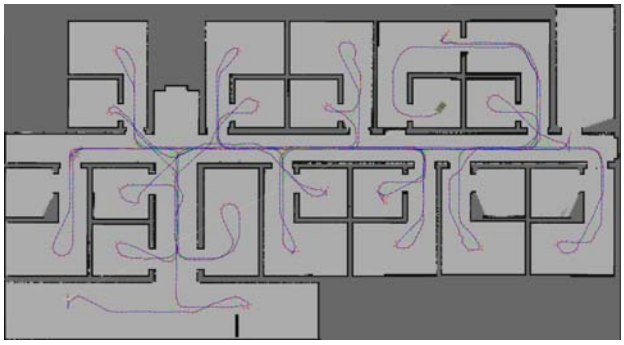
Research Objective

- **Develop framework for robust and efficient algorithms for autonomous mobile robot behaviors related to intelligence, surveillance, and reconnaissance (ISR) missions**
- **Expected measurement entropy models can be used to select actions to gather information quickly**
- **Metrics coupling robot localizability with information gain balance robustness with speed in a variety of challenging environments.**



Map built through autonomous exploration using information-gain metric

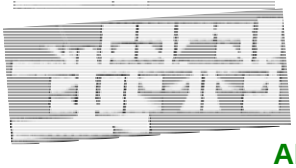
Challenges

- **Accurate, reliable, and timely ISR is needed for strategic planning**
- **Robot localizability is degraded in difficult Army relevant environments such as underground tunnels**

Approach

- **Exploration information-gain metrics based on : Stachniss et.al. "Information gain-based exploration using Rao-Blackwellized particle filters," RSS, 2005.**
- **Earlier results were based upon filter approaches to robot mapping. This method uses modern graph-based smoothing which admits more accurate loop closure predictions.**
- **Map entropy vs time is compared between information-based and baseline greedy nearest-first approaches.**
- **By adjusting a single weighting factor, safety can be traded for speed and coverage.**

Best "Baseline" exploration map out of 50 runs with large sensor noise



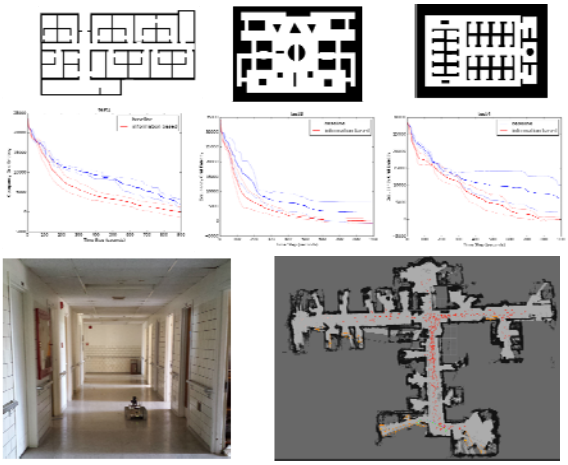
Best "Information-based" exploration map out of 50 runs with large sensor noise

ARL Facilities and Capabilities Available to Support Collaborative Research

- **Indoor experimental testbed at Adelphi campus**
- **Field experiments at military training facilities (MOUT)**
- **Specialized robot mapping, navigation, and control software suite**
- **Robot assets:**
  - Packbots (5)
  - Clearpath "Jackals" (7) and "Huskies" (3)
- **Robot communications infrastructure**

Early Results

- **Information-based approach superior to baseline greedy approach in simulated environments**
- **Initial results from live robot tests in operationally relevant environments indicate this to be a useful approach**
- **Approach is generalizable to other ISR tasks besides mobile robot exploration**
- **Exploration results extend state-of-the-art with graph-based loop closure prediction and evaluation**
- **Demonstrated that information-based approaches can deliver accurate, reliable, and timely ISR in challenging Army-relevant environments.**



Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Extend measurement entropy paradigm to other autonomous ISR missions to develop general framework.**
- **Evaluate alternatives which leverage TSP solvers and path-dependent rewards.**
- **Extend to multi-robot teams via auctions and optimal solutions to the vehicle routing problem.**

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