

NRI-FND-Probabilistic Hypothesis Driven, Adapting Human-Robot Teams

Award IIS-183049

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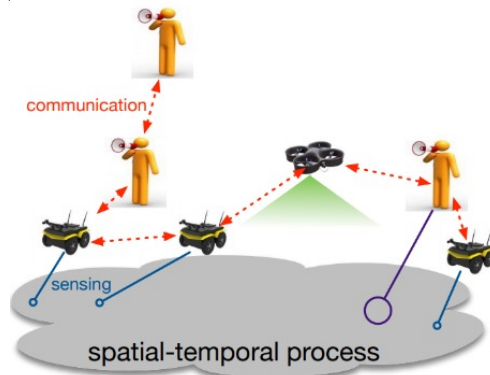
Cornell University

April 21st, 2022

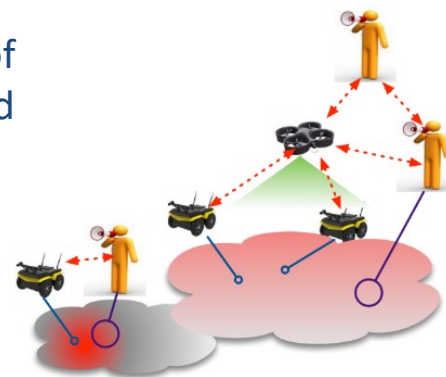
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Challenge

- Cooperation for human-robot teams operating in complex environments evolving over time



Evolution of
process and
teams

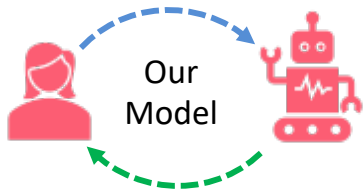


Novel Solutions:

- 1) Interaction based on **natural language**
- 2) Optimization for **multiagent teaming**
- 3) **Integration/Validation:** SaR mission, Firefighter input, Danger level inference, heterogenous planning with probabilistic constraints

Broader Impact

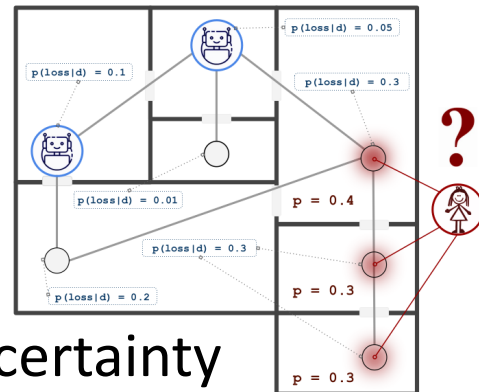
- Applications: SaR, homeland security, disaster response, ...
- Outreach activities w/ high schools



Recent Work

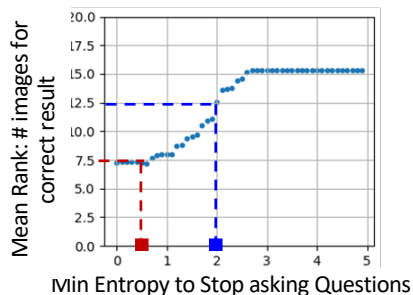


strategies, language, danger levels



Interactive Communication

- Robot infers which question to ask to reduce uncertainty
- Leverages language-based Re-ID
- Task related interactions
- High rate of task completion



MILP Multi-agent Planning with Uncertainty

- Fast and *scalable* probabilistic search
 - 90x faster than current state of the art
- Centralized and *distributed* solutions
 - multiple searchers
 - arbitrary capture ranges
- Current: Heterogeneous adaptive tasking

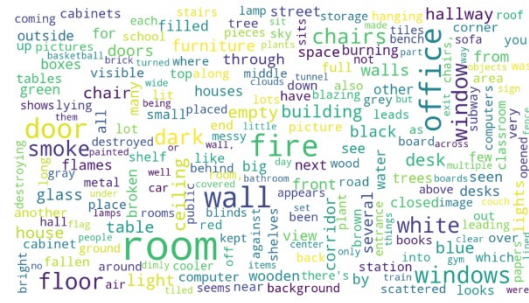
V Shree, WL Chao and M Campbell. "Interactive Natural Language-based Person Search," in RA-L, 2020
 Asfora, BA, Banfi, J and Campbell, M, 2020. Mixed-Integer Linear Programming Models for Multi-Robot Non-Adversarial Search. IEEE RA-L
 V Shree*, B Asfora*, R Zheng, S Hong, J Banfi, M Campbell. "Exploiting Natural Language for Efficient Risk-Aware Multi-robot SaR Planning," RA-L, 2021

Datasets: Images, Danger, Nat Language

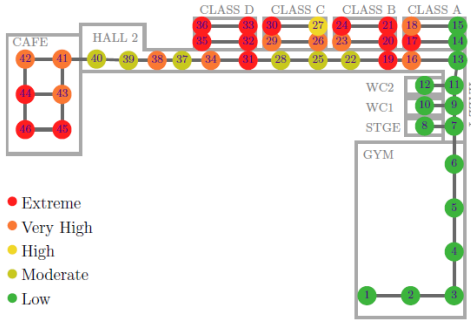
- Synthetic dataset
 - Simulated disaster images
 - 4000 sentence descriptions from AMT
- Movies and TV:
 - 15 movies, 5 TV shows
 - flooding, fire, earthquakes
 - 1000 images
 - annotated with danger levels and keywords
- Inferred Danger Level
 - Fuse similarity scores across images
 - Results demonstrate estimated danger to be similar to ground truth data



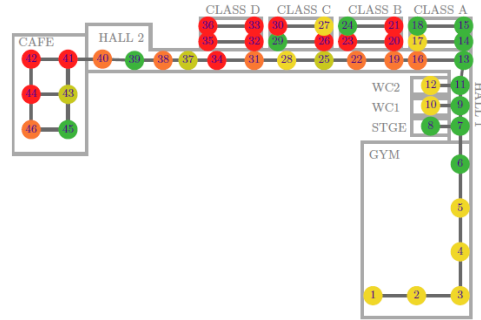
- A number of houses could be seen along the roadside. The place looks green.
- The houses are lit on fire and looks like a big accident has occurred.



Word-cloud of sentences



Ground Truth (AMT)



Inferred Danger

Human+Robot Fusion

- **Goal:** unify scene perception leveraging both robots' and humans' abilities.
 - **Robots:** visual detections, word inference
 - **Humans:** scene/danger descriptions
- **Bayesian fusion:** improves danger estimation by leveraging robot/camera + human language information
 - *Best of both worlds*
- **Risk-aware planner:** identify safer paths out of the dangerous environment
 - 19% higher success rate than all baselines
- Currently in RA-Letters review

