Enhancing Situational Awareness via Robotic Partners

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Motivation and Objective

- Robots may assist humans to explore their environment in time-sensitive and hazardous applications, like cave search and rescue.
- Create a robotic system that responds to human priorities while autonomously exploring a complex environment.

Figure 1: Caves exhibit diverse environmental conditions, including (left) vertical ascents and descents, (middle) confined spaces, and (right) uneven, complex terrain [Image Credit: D. Bristol].

Human-Robot Collaboration Challenges

- Physical/time constraints preclude explicit tasking
- Eye tracking performance is affected by low light settings.
- Gesture-based tasking impossible when hands unavailable
- Voice commands not accurately received in noisy environments

Sensing, Perception, Autonomy Challenges

- Uncertainty from environmental obscurants pose safety risks
- SWaP constraints limit available onboard compute
- Confined space access difficult for humans and robots

Scientific Impact

- Addresses the question of how to model, develop, and evaluate exploration algorithms to assist search and rescuers in the field
- Studies preferences for implicit communication in search and rescue tasks
- Tele-operation techniques to alleviate cognitive load while operating robots in confined spaces
- A new human-robot collaborative exploration paradigm, which leverages a sensing/compute payload mounted to helmet, to enable hands-free task allocation.

Proposed Research Thrusts and Preliminary Results

The proposed research thrusts are to:

1. investigate implicit communication preferences in SAR,
2. train model of human intent for implicit communication,
3. develop mathematical models to translate implicit communication into navigation tasks, and
4. develop safe confined space tele-operation methodologies.

Figure 2: Applying a spatial constraint (i.e., helmet mounted camera) to the exploration objective reduces uncertainty in shared human-robot map [1].

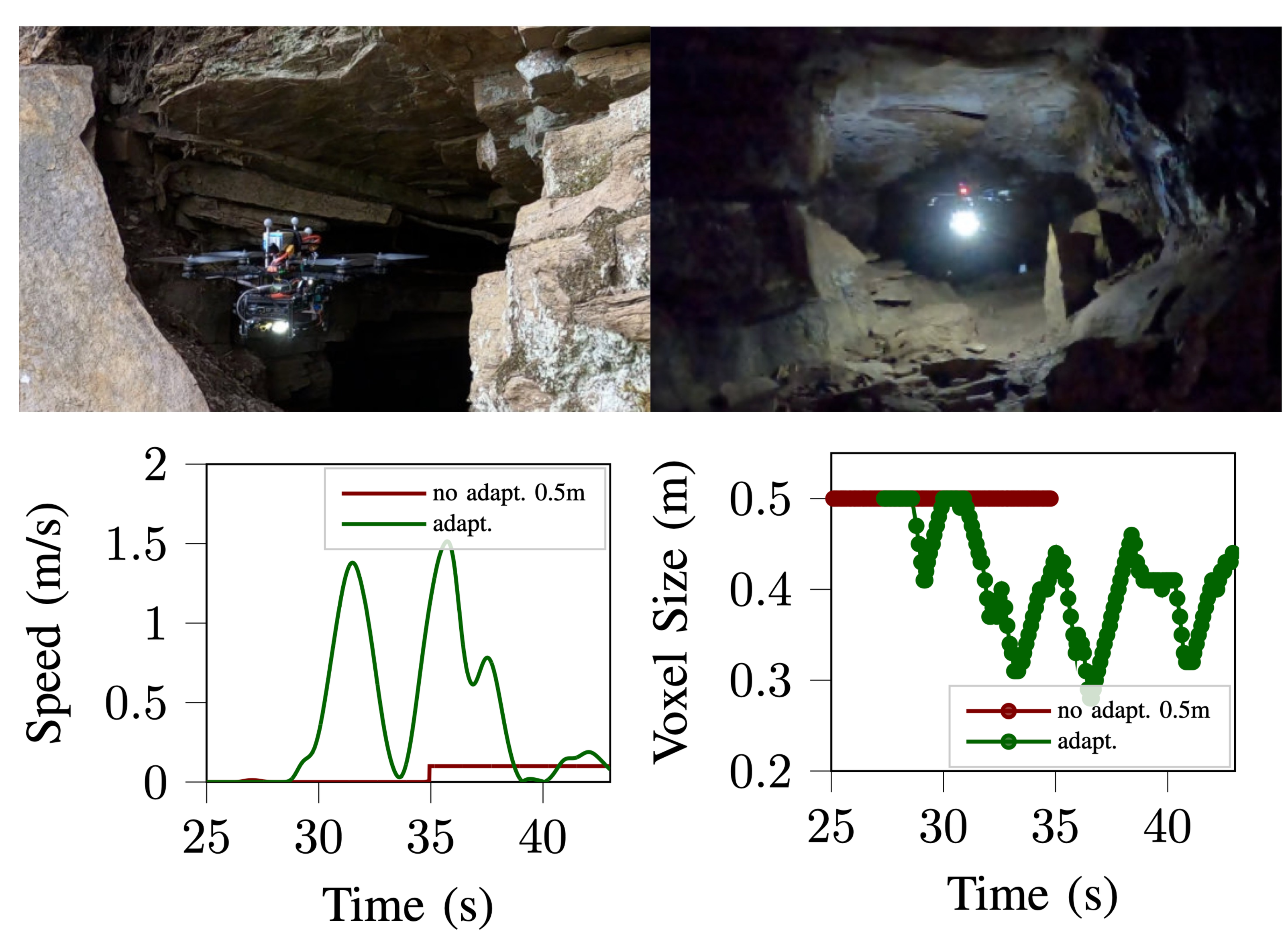

Figure 3: (Top) Teleoperated robot traverses cave passage. (Bottom) Robot speed adapts to environment complexity [2].

Broader Impact – Society

- Bridges the gap between field robotics, human robot interaction, and cave search and rescue.
- Scientific, medical, industrial applications

Broader Impact – Education

K-12 field test at local show cave to learn how to deploy robots in the real world.

Figure 4: Laurel Caverns show cave in Uniontown, PA.

Broader Impact – Evaluation

- Direct assessments to quantify robotics knowledge before and after field test
- Measure interest in pursuing a career in engineering/robotics before/after field test

[1] K. Goel, Y. G. Daoud, N. Michael, and W. Tabib, "Hierarchical Collision Avoidance for Adaptive-Speed Multirotor Teleoperation" IEEE International Symposium on Safety, Security, and Rescue Robotics. 2022. **Best Paper Award**.
[2] Y. G. Daoud, K. Goel, N. Michael, and W. Tabib, "Collaborative Human-Robot Exploration via Implicit Coordination" IEEE International Symposium on Safety, Security, and Rescue Robotics. 2022.

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