Ray W. Herrick Laboratories

Designing a Human Autonomy Teaming Platform to Research the Effect of Communication on Team Performance

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OVERVIEW

Human-autonomy teaming (HAT) is becoming critical across many sectors of society, particularly as autonomous systems (enhanced by AI) advance in capability. However, for humans to successfully team with robots, effective communication is essential [1]. The objective of this research is to design the appropriate algorithms to achieve adaptive, bi-directional communication among human-autonomy teams to achieve shared goals and outcomes.

[1] A. R. Marathe, K. E. Schaefer, A. W. Evans, and J. S. Metcalfe, "Bidirectional Communication for Effective Human-Agent Teaming," 2018,.

[2] M. Natarajan *et al.*, "Human-Robot Teaming: Grand Challenges," 2023.

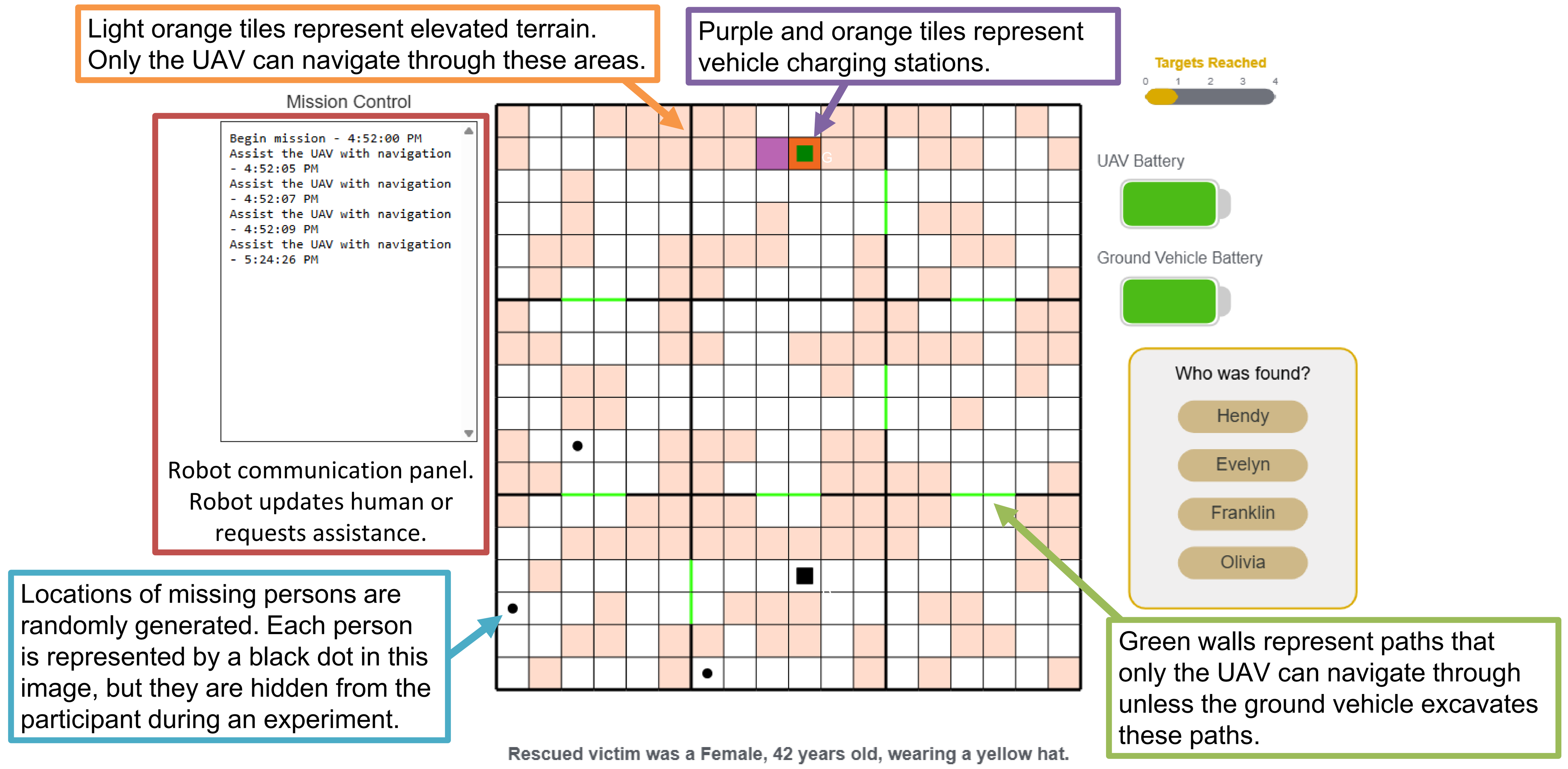

Fig. 1: Main interface of the human autonomy teaming platform where the UAV is represented by a black square and the ground vehicle is represented by a green square.

Experiment Design

Participant Objective: Work with an unmanned aerial vehicle (UAV) and ground vehicle to locate and identify four humans in a search and rescue scenario. Participants will be able to communicate with other teammates using natural language bidirectional communication.

- The experiment will be used to evaluate different features of communication, specifically the content and frequency, with a constant modality.
- Open-loop data will be collected by conducting one experiment that varies the frequency of communication and the another that varies the content of communication.
- Models of trust, workload, and situational awareness will be developed using the open-loop data. The models will be used to synthesize a policy that determines how to vary the communication features to improve team performance.
- Performance will be evaluated using metrics like completion time and victim identification accuracy.

Cognitive State	Measurement
Trust	Time manually controlling each vehicle
Workload	Response time to victim identification, completion time of mission
Situational Awareness	Victim identification accuracy, eye tracking

Experimental Testbed Functionalities

- In each mission, a map consisting of nine premade 6 x 6 grids is generated. The grids and the paths between grids are randomly selected so that each map is unique (Fig. 1).
- Each team member has unique capabilities:
  - The UAV can navigate through elevated terrain.
  - The ground vehicle can excavate paths.
  - Participants complete side tasks like identifying rescued persons, calibrating the robots, and assisting with complex navigation.
- The UAV and ground vehicle can navigate autonomously but are only about 70% efficient at navigation. The human can elect to take control of either robot and search manually.

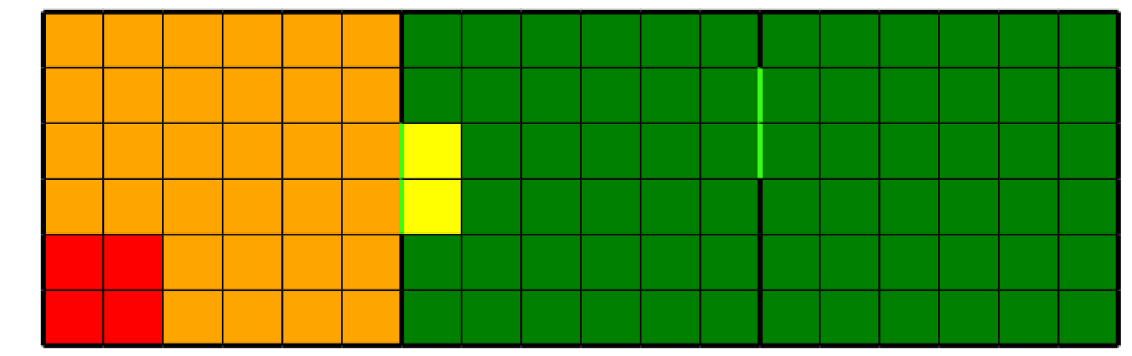

Fig. 2: Infrared image of map where red indicates locations with humans and green represents empty areas. Participants are shown this map prior to beginning a mission.

Communication Features

There are three main features of communication [2]:

1. Modality: Type of communication
2. Content: The information presented
3. Frequency: The rate of communication

Each feature can be evaluated to determine which are most effective at perturbing cognitive states and affecting performance.

This work will focus on a natural language modality since it tends to be the most intuitive modality for the general population [2].

Future Work

- Collect human subject data to evaluate effectiveness of platform in perturbing cognitive states via changes in content and frequency of delivery.
- Develop model to relate communication features, human cognitive states, and teaming performance metrics.
- Develop an optimal control policy for improving team performance.

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