HRTeam: A Framework to Support Research on Human/Multi-Robot Interaction

(Demonstration)

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ABSTRACT

The *HRTeam* framework supports research on discovering and evaluating methods for addressing a range of issues in human/multi-robot team interaction. Three sample tasks illustrate the methods currently being investigated: *mission selection*, dictated by a human operator; *collision avoidance*, taught by a human trainer; and *targeted exploration*, jointly achieved with a human collaborator. Physical and simulated multi-robot environments are used to support this research.

Categories and Subject Descriptors

I.2.9 [**Robotics**]: Miscellaneous

Keywords

Multi-Robot Systems, Human-Robot Interaction, Multiagent Coordination

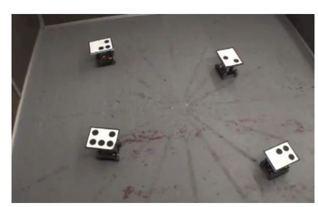
1. INTRODUCTION

Our research addresses issues that are well-studied in *virtual* or *simulated multiagent systems (MAS)*, but present difficulties when implemented in *physical multi-robot systems (MRS)*. The focus here is on tasks that require coordinated exploration, in situations that could benefit from shared decision making and settings that should be robust to dynamic changes in team composition. Our long term goal is to identify MAS approaches that are well-suited to MRS settings, as well as to devise approaches that address particular MRS challenges. Example experimental scenarios considered in our work include search and rescue [1, 7, 10], humanitarian de-mining [3, 5], and the treasure hunt game [6].

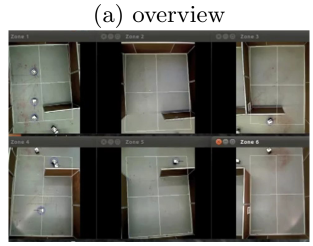
The overall philosophy behind our *HRTeam* framework takes a "rough-and-ready" approach. We deploy a team of multiple low-end robots and distribute exploration tasks across team members. With robotics, practical constraints always present difficulties. These issues are especially prevalent with inexpensive robot platforms. For example, the quality of images obtained from low-end cameras may be poor; processing may be either relegated to limited robot processors or distributed to networked laptops or desktop computers; and network connectivity may be slow and intermittent. Because transfer from the laboratory setting to the "real world" will require methods that perform well in the face of such practical difficulties, we take advantage of these opportunities to investigate solutions that are robust to such challenges, rather than try to eliminate them in our lab by using higher-quality equipment.

We have developed the HRTeam framework to support experimental research in human/multi-robot interaction in both physical and simulated environments [8]. MAS approaches can be rapidly prototyped and assessed in simulation, and then tested more thoroughly with physical robots. Our current research efforts involve a number of key challenges, such as *coordination* across a range of task classifications (based on team size, task repetition, inter-task dependence and multi-task composition) and *shared decision-making* between human and robot team members. This demonstration focuses on aspects of these challenges.

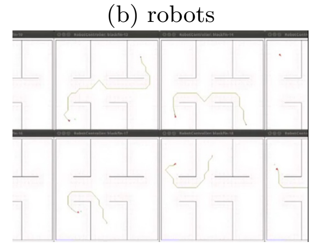
(a) overview



(b) robots



(c) cameras



(d) visual debugger

Figure 1: HRTeam framework

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2. SYSTEM OVERVIEW

Figure 1 illustrates components of the HRTeam framework. Figure 1a is a bird's eye view of the arena, which contains six rooms and a hallway. Figure 1b shows four of the robots. Each robot is a Surveyor Blackfin[1], wearing a Braille "hat" that can be used to identify the robot [9]. A network of six cameras is suspended above the arena to provide "global positioning" information for the robots. Figure 1c shows the view from each of the six cameras, with eight robots in the arena. Each robot is controlled autonomously using *SemaFORR*, a cognitively plausible robot control architecture based on FORR [2]. Each controller process has its own "visual debugger" window, as depicted in Figure 1d. The low-level functionality of the robot controller is based on Player/Stage [4]. This makes it easy for the HRTeam system to support simulation (using Stage).

3. DEMONSTRATION TASKS

The experimental arena is used to evaluate our methods for handling several different kinds of tasks, in both simulation and physical modes. A *human operator* interacts with the team to accomplish any of the tasks listed below.

(a) learning from operator (b) looking for objects

Figure 2: User interfaces

Mission definition. The human operator clicks on the *operator interface* component of the system to indicate multiple locations—"interest points"—that the team of robots should visit or search. The operator can vary the number of locations (e.g., more than the number of robots, equal to the number of robots, fewer than the number of robots). The robots distribute the interest points amongst themselves using a pseudo-auction mechanism. Then they start their mission, beginning near to each other in a clustered formation. Two types of missions may be attempted: an *achievement* mission, wherein all interest points must be visited once and then robots return to their starting locations; or a *maintenance* mission, wherein robots continuously visit their assigned interest points.

Collision avoidance. The human operator has the ability to pause and resume the motion of any robot (Figure 2a). This facility can be used to prevent robots from colliding with walls, each other or other obstacles that may be present in the environment. Our system collects data on the state of the robots' environment when the human issues a "pause" or "resume" command. This data is mined to train the system to perform collision avoidance more effectively.

Targeted exploration. The operator interface station is separated from the arena (simulated or physical) so that the human operator cannot view the robots' environment. The only information s/he has about the environment is provided by robots' sensors (cameras and range sensors). Multiple objects of interest are placed in the arena in secret locations, and the human operator's job is to collaborate with the robots to find them. The operator can indicate to the robots which "rooms" in the arena to search (Figure 2b). The robots can transmit pictures from inside the rooms back to the human operator, for identification of objects. The exploration run is timed, and the human is scored based on the number of objects found and correctly identified. The time limit puts constraints on the number of rooms that can be visited and the number of images that can be transmitted.

[1] `http://www.surveyor.com`

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