TeamTalk: A platform for multi-human-robot dialog research in coherent real and virtual spaces

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Abstract

Performing experiments with human-robot interfaces often requires the allocation of expensive and complex hardware and large physical spaces. Those costs constrain development and research to the currently affordable resources, and they retard the testing-and-redevelopment cycle. In order to explore research free from mundane allocation constraints and speed-up our platform development cycle, we have developed a platform for research of multi-human-robot spoken dialog in coherent real and virtual spaces. We describe the system, and speculate on how it will further research in this domain.

Introduction

TeamTalk is an application of the Olympus spoken dialog framework with modifications to support a live map GUI and robot agent back-ends. Originally, it was written as a spoken language interface seminar class project and represented an interface for the Carmen (Montemerlo, Roy, & Thrun 2003) robot platform. Subsequently, it became the interface component for the Boeing Treasure Hunt project, whose main objective was to investigate support for ad-hoc multi-human multi-robot team formation and execution in a treasure-hunt scenario. The Boeing Treasure Hunt project combined resources from three research groups: TeamTalk (interface support), TraderBots (Dias *et al.* 2004) (market-based task allocation and mapping), and CM-RMP (Browning *et al.* 2004) (coordination and visual processing support).

Over two years time, a combined system has been developed. The system is currently used for experiments in co-ordinated multi-human-robot search in dynamic indoor environments. The robots include multiple Pioneer P2DX's, as well as a Segway RMP. High-level search-domain tasks can be introduced by the human team members, as well as low-level tasks such as simple navigation commands. The human team members can conduct spoken dialogs with particular robots about those tasks, and also refer to a live map that is updated and annotated by the robots. Such annotations include robot positions, estimated treasure positions, and current robot intentions.

A communications specification was established that enables heterogeneous robots to form ad hoc teams. Those teams can then execute co-ordinated sets of actions in the pursuit of high-level domain-specific tasks. The utility of those specifications was tested when a group of researches from our Boeing integrated the specification into their own robot, whose control code with no common basis with the rest of the project's robots. After approximately one day of integration work, the Boeing robot was able to bid and execute those high-level domain tasks properly under the specification.

The system is functional, but as a research platform it is not simple to operate and lacks some robustness. While this is common for research systems, it can be especially true for those systems that attempt to be generic to underlying hardware or perform in real dynamic environments. Testing the overall system requires the coordination of time and space from several busy researchers. Issues with robustness limit the amount of time that a single experiment is feasible before restarts are required, and real-world issues such as battery life often end experiments prematurely. All of these things are indications that a virtual test environment would be beneficial to the project and the research.

USARSim Integration

As we had developed a communications system for the integration of heterogeneous robots, there existed a natural path to the integration of virtual robots into the system as well. We chose to do this integration with MOAST-based virtual robots running in the USARSim simulation environment. USARSim (Wang & Balakirsky 2006) is an open source simulation environment originally developed to support research and evaluation of tele-operated urban search and rescue robot controls. It leverages Unreal Tournament 2004, a commercial 3-d game engine, for physics simulation, robot vehicle models, and real-time visualization. MOAST (Balakirsky 2006) is an open-source modular mobile robot platform with SLAM and an autonomous mobility planner. MOAST's ”simware” component substitutes for robot hardware and allows it to interface directly with the USARSim environment as a robot vehicle. Several virtual environments have been developed and published for the USARSim system. Our testing to date has used those environments, but we plan to model some test environments that are coherent with the real spaces that we operate with.

The USARSim server runs on one machine. The MOAST-based virtual robots are spawned on a Linux cluster as needed. The human participant interacts with the robots through the speech and map interface, and simultaneously interacts physically with the environment through an unmodified Unreal game client. In this way we have created a system to explore multi-human-robot teamwork in a virtual space.

Research

We believe that research on face-to-face multi-human-robot dialog cannot be done adequately though the analysis of dialog corpus, nor even through low-fidelity simulation. s, nor even through low-fidelity simulation. Valid results must come from either experiments in the real world or through high-fidelity simulation such as we are attempting under the USARSim environment. We briefly discuss two research thrusts that we wish to pursue: multi-participant dialog, and grounding concepts language and experience.

Multi-party dialogs adhere to interaction principles that, if ignored, break down communication in team activities. We have developed some simple strategies for dealing with the most salient of these principles. The TeamTalk system deals properly with agent addressees, out-of-turn agent-interruptions (robots' asynchronous tasks may require the interruption of an ongoing dialog), and channel contention. We are currently looking into two additional challenges related to multi-participant dialog. We are interested in how to address sub-groups of agents, and how one agent may offer proxy responses for a group of agents. As supported by the game-engine visualization, being able to actually see the agents and address them while they are preforming these tasks is essential for eliciting natural behavior in these situations.

Robotic systems are generally built with very specialized domains in mind. This limits their usefulness and increases their cost. One of the grand challenges that faces robotics is building robots that learn about their environments, and as such become more flexible and adept in the applications they find themselves needed for. But learning from one's environment without supervision usually leads to sub-optimal learning. We will use this platform to experiment with robot learning through dialog with humans that share the environment. Our robots will learn about their environment through the grounding of linguistic concepts in sensor data experience.

Virtual Environment Benefits

We expect to benefit from this coherent high-fidelity virtual environment in three ways: it will speed up our development cycle, it will improve coordination with developers not physically resident at the University, and it will allow us to experiment with parameters that cannot be duplicated in the real world due to resource constraints.

As discussed in the Introduction, due to scheduling constraints there are sometimes delays for tests and experiments. When experiments are scheduled, a failure in one component or issues with hardware or supporting machinery may result in an inconclusive test. Testing in a virtual environment will eliminate many of these constraints. While it cannot completely replace the validity of real-world experiments, it will certainly improve the systems between times when such real-world experiments can be conducted.

We would like to coordinate more closely with off-site developers, and particularly with out project sponsor, Boeing. Although we share code, email, and hold conference calls, the cost of transporting people and robots between ends of the North American coast has left us with only one shared experiment. The high-fidelity virtual environment will enable coordinated experiments without those costs.

In the investigation of multi-party coordination and dialog interaction principles, it is natural to ask if what works for one number or agents will generalize to some other number of agents. We generally have on the order of four working robot at our disposal at any one time. Our coordination and interaction principles seem sound for that number, but it is unclear for the moment how that will scale. By utilizing the relatively unhindered virtual resources of our virtual MOAST-robot Linux clusters, we believe that a swarm of at least twenty dialog-capable robots may be a feasible experiment in the near future.

Conclusion

By allowing our spoken language and map-based interaction system to interact identically with real-world robots and virtual robots in a coherent virtual space, we believe that our future research will greatly benefit. We have built a platform for multi-human-robot dialog research that will enable rapid-prototyping, easier collaboration across distances, and a freedom to conduct otherwise costly experiments. We expect a better understanding of multi-participant dialogs and grounding in language. Please refer to the project's wiki, `http://edam.speech.cs.cmu.edu/teamtalk`, for more information.

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