Phase II Project Summary

Firm: Intelligent Automation, Inc
Contract Number: NNJ07JB29C
Project Title: An Integrated Human System Interaction (HSI) Framework for Human-Agent Team Collaboration: Phase II: The Human-Autonomous System Interaction

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)
The innovation is the development of a novel, protocol-based human–autonomous system interaction (HASI) framework. The core of HASI is the Team Work Effort protocol for autonomous robots engaged in mission tasks, under the supervision of an Astronaut, with safety, problem –reporting, and re-charging protocols. HASI protocols were developed, tested in simulation and then deployed to physical hardware. A robot operating system (ROS), IAI's Distributed Control Framework, was modified to allow a robot to be protocol aware. This approach will work for any ROS that is agent-aware.

The significance is the protocols for an autonomous, mission-oriented robot team that is acting according to the role-based Team Work Effort protocol, with multiple ancillary protocols that support the general situation. The HASI framework allows additional protocols to be defined. The Astronaut is integrated into the autonomous robot Team Work Effort protocol as an oversight entity that communicates directly with the Team Leader robot. (The Team Work Effort protocol has roles for the robots.) This preserves the autonomy of the robot team, but fits it into the larger HASI framework. To support safety, the Astronaut may communicate directly with each robot. We also support a CORBA bridge between the Astronaut and the robot(s).

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)
The primary technical objective is development of the HASI Framework. This includes development of a primary role-based Team Work Effort protocol as well as multiple ancillary protocols that support the general situational awareness in task activities. This includes protocols form problem-reporting, for Astronaut nearness, etc. A second key technical objective is deployment of the protocols to a robot team for testing.

The work plan involved: (1) Development and software implementation of HASI protocols, (2) Modification of the 'Robot Agent' that is an abstraction in IAI's Distributed Control Framework (DCF), a robot operating system, to be cognitively enhanced and protocol-aware, (3) design of a notional Scientific Sampling Mission in the Lunar Environment, (4) testing of the HASI protocols and the enhanced DCF to hardware robots in simulation, (5) deployment of the HASI protocols and the enhanced DCF to hardware robots for testing in the lab and (6) development of a CORBA bridge so that the protocol-utilizing autonomous robot agent team could communicate with the same approach that is currently used by NASA.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)
Technical accomplishments include: (1) HASI protocols: the Team Work Effort protocol for autonomous robots engaged in mission tasks, under the supervision of an Astronaut, with Safety protocols (Safing in presence of an Astronaut, Collision Avoidance for mobile robots, Claim Staking for task areas), Problem – reporting, and Re-charging, (2) design and development of a protocol-aware and cognitively enhanced 'Robot Agent', (3) deployment to hardware and operation in the lab. These technical accomplishments were reported in multiple technical papers, citations are below:

- M. Lyell and W. Drozd, 'Protocol-aware, Enhanced Cognition Robot Agent Design for Team Work Effort in Lunar Exploration Missions', Practical Cognitive Agents and Robots Workshop Proceedings, pp. 30-37, AAMAS 2010.
- M. Lyell and W. Drozd, 'Human-Autonomous System Interaction Framework to Support Safety in Astronaut-Robot Team Interactions', AIAA Paper AIAA-2010-764, 2010.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)
NASA applications are those which involve autonomous robot team applications, under the supervision of an Astronaut. This includes the robot team autonomy applications for Lunar Outpost Missions, Scientific Sampling Missions, etc. The robot team, under the direction of a robot team leader, also may be under the supervision of an Astronaut. An Astronaut is also able to interact directly with a specific Robot to inquire about status or to order safing/desafing.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)
Non-NASA applications are those which involve robot teams. Commercial areas in which this technology is appropriate are in warehouse operations, in manufacturing where there is a requirement for robot team mobility, in search and rescue.

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