Fiscal Year:	FY 2014	**Task Last Updated:**	FY 06/10/2014
PI Name:	Sandor, Aniko Ph.D.		
Project Title:	Assessment, Evaluation, and Development of Methodologies, Metrics and Tools Available for Use in Multi-agent (Human and Robotic) Teaming		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	09/07/2012	**End Date:**	12/31/2014
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:	NOTE: Project ended 12/31/2014 per E. Connell/JSC HRP (Ed., 6/15/15)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Cross, Ernest Ph.D. (Lockheed Martin/NASA Johnson Space Center) Chang, Mai Lee (NASA Johnson Space Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The study of human-robot interaction (HRI) involves understanding and shaping the interactions between humans and robots (Goodrich & Schultz, 2007). It is important to evaluate how the design of interfaces and command modalities affect the human's ability to perform tasks accurately, efficiently, and effectively (Crandall, Goodrich, Olsen Jr., & Nielsen, 2005). Many NASA robot systems are teleoperated. Developing safe, reliable, and effective human-robot interfaces for teleoperation involves providing the information necessary to support operator task performance. For robot navigation tasks, which include the operator moving a robot through space or commanding individual robot segments, the operator needs to understand the current and desired state of the robot, and have the most compatible command modality with the task. In Fiscal Year 2011 (FY11), preparatory work was completed in the form of literature reviews; observations of NASA robot systems; interviews with NASA robotic operators and trainers; and a space HRI workshop. These activities resulted in the selection of three research areas that are the focus of the proposed work. The three research areas are: Video Overlays, Camera Views, and Command Modalities. Studies proposed in this Directed Research Project in the area of Video Overlays consider two factors in the implementation of augmented reality (AR) for operator displays during teleoperation. The first of these factors is the type of navigational guidance provided by AR symbology. Participants' performance during teleoperation of a robot arm will be compared when they are provided with command-guidance symbology (i.e., directing the operator what commands to make) or situation-guidance symbology (i.e., providing natural cues so that the operator can infer what commands to make). The second factor to be considered for AR symbology is the effect of overlays that are either superimposed or integrated into the external view of the world. A study is proposed that compares the effects of superimposed and integrated overlays on operator task performance during teleoperated driving tasks. Studies proposed in the area of Camera Views investigate inclusion/exclusion of a robot within the video feed and camera frame of reference. One study will investigate the effects of including and excluding the robot's chassis within the video feed presented to operators on path-following and maze traversal task performance. Another study will investigate the effects of the addition of an exocentric camera frame of reference to egocentric frames of reference on operator task performance for these same tasks. Lastly, studies in the area of Command Modalities will systematically build and evaluate gesture and voice vocabularies for commanding a ground-based mobile robot. The first in this series of studies will have participants produce robot commands for a set of critical control functions. The characteristics of the commands will be analyzed. In a second phase of this study, the strength of association between command and voice/gesture inputs will be evaluated. The next two studies will test the learnability and memorability of the developed vocabularies in the context of a representative task.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The video overlays developed by the research projects can be applied to any type of robotic teleoperation situation. The results of the camera view studies will be applicable to mobile robots such as rovers and search and rescue robots. Finally, the method applied and tested for the development of a gesture and voice command vocabulary can be used for any other system to develop similar kinds of communication systems.
Task Progress:	Human-Robot Interaction (HRI) is a discipline investigating the factors affecting interactions between humans and robots. It is important to evaluate how the design of interfaces and command modalities affect the human's ability to perform tasks accurately, efficiently, and effectively when working with a robot. By understanding the effects of interface design on human performance, workload, and situation awareness, interfaces can be developed to appropriately support the human in performing tasks with minimal errors and with appropriate interaction time and effort. Thus, the results of research on human-robot interfaces have direct implications for the design of robotic systems. This research project concentrates on areas associated with human-robot interfaces applicable to NASA robot systems. One area of research focused on video overlays. The first study investigated how Augmented Reality (AR) symbology can be added to the human-robot interface to improve teleoperation performance. Three types of AR symbology were explored in this study, command guidance (CG), situation guidance (SG), and both (SCG). CG symbology gives operators explicit instructions on what commands to input, whereas SG symbology gives operators implicit cues so that operators can infer the input commands. The combination of CG and SG provided operators with explicit and implicit cues allowing the operator to choose which symbology to utilize. The objective of the study was to understand how AR symbology affects the human operator's ability to align a robot arm to a target using a joystick and the ability to allocate attention between the symbology and external views of the world. The study evaluated the effect of type of symbology (CG and SG) on operator task performance and attention allocation during teleoperation of a robot arm. A second study is looking at superimposed and integrated overlays for teleoperation of a mobile robot using a hand controller. When AR is superimposed on the external world, it appears to be fixed onto the display and internal to the operators' workstation. Unlike superimposed overlays, integrated overlays often appear as three-dimensional objects and move as if part of the external world. Studies conducted in the aviation domain show that integrated overlays can improve situation awareness and reduce the amount of deviation from the optimal path. The purpose of this ongoing study is to investigate whether these results apply to navigation with a mobile robot.
Bibliography Type:	Description: (Last Updated: 03/03/2016)
Abstracts for Journals and Proceedings	Sandor A, Cross EV 2nd, Chang ML. "Human-robot interaction." Presented at the 2014 Human Research Program Investigators' Meeting, Galveston, TX, February 12-13, 2014. 2014 Human Research Program Investigators' Meeting, Galveston, TX, February 12-13, 2014. http://www.hou.usra.edu/meetings/hrp2014/pdf/3049.pdf , Feb-2014
Abstracts for Journals and Proceedings	Sandor A, Cross EV 2nd, Chang ML. "Human-robot interaction: overlays for teleoperation." Presented at the Southwest Regional Human Factors and Ergonomics Society Symposium, College Station, TX, June 6, 2014. Southwest Regional Human Factors and Ergonomics Society Symposium, College Station, TX, June 6, 2014. , Jan-2014