Fiscal Year:	FY 2015	**Task Last Updated:**	FY 06/16/2015
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		
PI Email:	Aniko.Sandor-1@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	281.483.9726
Organization Name:	Lockheed-Martin/NASA Johnson Space Center		
PI Address 1:	2101 Nasa Parkway		
PI Address 2:	Mail Code: C46		
PI Web Page:			
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:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmore, Mihriban	**Contact Phone:**	281-244-1004
Contact Email:	mihriban.whitmore-1@nasa.gov		
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:	Teleoperation is usually accomplished with the use of one or multiple camera views. The amount and type of information provided by the limited view of cameras can lead to reduced situation awareness, increased task times, and errors. The use of augmented reality, in the form of overlays, is one approach that may compensate for the issues associated with teleoperation with video feed. A series of studies were conducted to investigate the effect of overlays on teleoperator performance. The first study investigated the effects of situation and command guidance overlays on operator performance when teleoperating a robot arm and found that command guidance led to better performance than situation guidance. The combination of command and situation guidance seemed to have too much information and was more difficult to interpret than the other guidance conditions. The second experiment was a pilot study that considered the use of integrated and superimposed overlays for a teleoperated navigation task. The results were consistent with the literature: participants had higher number of collisions with the integrated overlays than with the head-down display, though in this condition participants were also slower. Since this study was conducted only with five participants, statistical inferences cannot be drawn from these results. The third study used redesigned versions of the superimposed and integrated overlays in normal and degraded visual condition. The results of this study showed no effect of overlay or visual condition on driving performance as measured by the number of collisions, speed, task completion time, or situation awareness. Follow-on studies need to investigate these types of overlays with improved designs and in more realistic environments.
Bibliography Type:	Description: (Last Updated: 03/03/2016)