HRI... in SPACE!!!

The future of HRI in Space

Tim and his friends face instant destruction from fierce robots on the PLANET OF DOOM!
Robonaut 2
Papers

Evaluation of Human and Automation/Robotics Integration Needs for Future Human Exploration Missions

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Human-Robot Exploration

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Goal: Create human and automation/robotic (HAR) task lists for each of 4 mission types:

- Deep Space Sortie
- Lunar Visit/Habitation
- Deep Space Habitation
- Planetary
Paper 1 - Methodology

How: NASA uses Design Reference Missions (DRM) to plan missions.
Assess critical factors and needs for success of HARI in each DRM.
Use the Human Research Program (HRP) as a guideline.
HRP studies human health and performance risks, including risk of inadequate HARI Design.
The assessment conducted focuses on a set of DRM categories, defined in the HRP Requirements Document.
## Table 1: Human Research Program Design Reference Mission (DRM) Categories

<table>
<thead>
<tr>
<th>DRM Categories</th>
<th>Mission Duration</th>
<th>Gravity Environment</th>
<th>Radiation Environment</th>
<th>Earth Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Earth Orbit (LEO)</td>
<td>6 months</td>
<td>Microgravity</td>
<td>LEO – Van Allen</td>
<td>1 day or less</td>
</tr>
<tr>
<td>Low Earth Orbit (LEO)</td>
<td>1 year</td>
<td>Microgravity</td>
<td>LEO – Van Allen</td>
<td>1 day or less</td>
</tr>
<tr>
<td>Deep Space Sortie</td>
<td>1 month</td>
<td>Microgravity</td>
<td>Deep Space</td>
<td>&lt; 5 days</td>
</tr>
<tr>
<td>Lunar Visit/Habitation</td>
<td>1 year</td>
<td>1/6 G</td>
<td>Lunar</td>
<td>5 days</td>
</tr>
<tr>
<td>Deep Space Journey/Habitation</td>
<td>1 year</td>
<td>Microgravity</td>
<td>Deep Space</td>
<td>Weeks to Months</td>
</tr>
<tr>
<td>Planetary Visit/Habitation</td>
<td>3 years</td>
<td>Fractional</td>
<td>Planetary</td>
<td>Months</td>
</tr>
</tbody>
</table>

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Paper 1 - Methodology

HARI experts review DRM s and identify HAR tasks.

Def: *HAR tasks are those activities (or tasks) identified in the DRM s, where operators in spaceflight (i.e., astronauts) or on Earth must complete using some automated or robotic system.*
Paper 1 - Methodology

Task Types:

- Spacecraft Guidance
- System Management
- Robotic Operations
- Mission Planning
Paper 1 - Methodology

Task Types:

- Spacecraft Guidance
- System Management
- Robotic Operations
- Mission Planning
Robotic Operations Tasks

Assembly tasks

Spacecraft support tasks

Science and assigned activity support tasks

Exploration tasks
Assembly Tasks

Complex:

- Capture and Berth: assembly tasks that require a robotic agent to grab and hold a large spacecraft, vehicle or module.
- Heavy lift: assembly tasks that require a robotic agent to move a large spacecraft, vehicle or module.
Assembly Tasks

Site preparation assembly task:

- **Excavation**: assembly task that requires robotic agent to dig up and/or move large amounts of soil, regolith, or subsurface bedrock.
**Spacecraft Support tasks**

**System maintenance:** tasks that require robotic agents to conduct spacecraft maintenance, typically mundane and/or repetitive. Maintenance may be conducted on subsystems, e.g., habitat filter system, while more complex maintenance may include servicing other robotic agents.

**System preparation:** tasks that require robotic agents to build, repair and/or conduct emergency care on spacecraft, vehicles, or other subsystems. These tasks would be the responsibility of robotic agents when the crew is unavailable (e.g., not on site) or because the task is too dangerous for the crew (e.g., nuclear power system).
Science & assigned activity support tasks

Science/sample collection: tasks that require robotic agents to collect and manipulate terrain samples.

Payload assistance: tasks that require mobile robotic agents to autonomously transport items for the crew’s use.

Crew assistance (physical): tasks that require robotic agent to collect, hold, and handle specific items, such as tools. These tasks require the robotic agent to cooperate directly with crew.
Science & assigned activity support tasks

Crew assistance (cognitive): tasks that require an autonomous agent to provide information and/or make decisions that will help crew complete and execute assigned tasks.
Exploration tasks

Scouting: tasks that requires mobile robotic agent to explore terrain of planetary body. Exploration may be on the surface, from above the surface, or sub-surface.

Mapping: scouting but with pre-determined science objectives. This implies the continuous use of scientific instruments and data collection.

Sampling/analyzing: tasks that requires mobile robotic agents to collect and analyze surface or sub-surface samples.
Human-Automation-Robotic Interactions

Monitor

Command

Command & Monitor
Human-Automation-Robotic Factors

Communication Infrastructure: No communication issues, some communication latencies, long communication lags with limited bandwidth.

Spacesuit Environment: Suited / unsuited

Gravitational Environment: Microgravity, partial gravity, and hyper gravity.

Colocation (Operator Proximity): Operator inside or close to system, operator is outside or far from system, and operator is on Earth.

System Diversity: The expected number and/or distribution of automation/robotic agents operator will interact with at any given time
Discussion & Conclusion

Assessing the DRMs was too high-level to be sufficient.

ISS astronauts already have limited time for research, and on surface missions astronauts will likely face an increase in time spent on maintenance.

Therefore, many potential tasks were left unspecified by this assessment.
Paper 1 - Questions

Why? Is this worthwhile?

How? Do you agree with Methodology?

What? Do you agree with their findings?

What next? Is this useful?
“He just doesn’t get me.”
Space exploration as an opportunity to develop social robotics.

Prolonged social isolation increases the tendency to anthropomorphise nonhuman agents.
The goal of social robotics in a space exploration context is to constructively develop an illusion of human traits in a machine in order to either help manage a need for a degree of social interaction, or to extend human sensing and action through more immersive telepresence robotics.

Q: Can the illusion of humanness in robots can be constructively maintained over time to assist in social contexts?
Symbolic Interactionism

- "Humans act toward things on the basis of the meanings they ascribe to those things."
- "The meaning of such things is derived from, or arises out of, the social interaction that one has with others and the society."
- "These meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he/she encounters."
How we fundamentally define and interpret a humanoid robot depends on how we define a human being.
Social interaction involves an act from an individual that calls out for a response that is either absent or illusory in interactions with nonhuman agents and objects.

Social robots look to simulate and evoke social responses.

The illusion of autonomy + the human tendency to anthropomorphise = interaction between humans and objects empowered with agency.
Paper 2 - Embodied Social Interaction

The body itself is a social object where meanings are constructed in a given cultural context.

Through our bodies and senses we interact, perceive, and express ourselves.

In robotics, embodiment typically refers to its physical existence in the real world and the notion of action-reaction states between the robot and its physical environment.
Prolonged isolation increases the tendency to seek a social connection, including the tendency to anthropomorphise nonhuman agents, physical or virtual.

The challenge remains as to whether such an illusion can be maintained over time.

The results of HRI studies involving space crews would prove beneficial for other cases of socially isolated individuals.

- Robot companions for the elderly, children with autism, etc.
Paper 2 - Space Robot Design

Humanoid robots

Purposefully anthropomorphomic robot design and exploiting the human tendency to project human traits onto inanimate objects.

Space robots use both.
Kirobo

The first robot designed merely for social interaction in space

“The Kibo robot has a special mission: To help solve the problems brought about by a society that has become more individualised and less communicative. Nowadays more and more people are living alone. It’s not just the elderly – with today’s changing lifestyle it’s people of all ages...”
Telepresence

- Purposefully extend the human operator
- Telepresence > teleoperation
- Use humanoid space robots that resemble the human body and its senses
- Facilitate a stronger sense of immersion
Telepresence

- “the most natural technical solution” for controlling a moving machine
- Um... Driving?
- teleoperators of humanoid robots may experience “body ownership transfer”; feel as if robotic bodies were their own
- Embodiment!
Paper 2 - Space Robot Design

Rovers

- interactive collaborators with humans
- Because of their exploratory functions, Mars rovers are often explicitly anthropomorphised by researchers and the public.

Deliberate anthropomorphisation

- Rovers have Twitter Accounts
Paper 2 - Space Robot Design

Person Exploration Rover

- Designed to help educate the public about the NASA Mars Exploration Rover mission.
- The specific goal of the study was to understand how the *cognitive model* of the robot changes over time.
We already anthropomorphise space robots, humanoid or otherwise.

Isolation will increase this tendency, thereby making space exploration a key environ in which to research social robotics.

Strengthen the link between robots and humans via humanoid robots in an attempt to maintain the illusion of humaness in nonhuman objects for long periods of time.

Apply this knowledge of HRI to other contexts involving socially isolated individuals.
Paper 2 - Questions

Why? Is this worthwhile?
How? Do you agree with Methodology?
What? Do you agree with their findings?
What next? Is this useful?