

From UbiComp to Universe — Moving Pervasive Computing Research Into Space Applications

> Kelvin Egbine Nicola Ferraresi



Introduction

PERVASIVE COMPUTING IN SPACE

- The transformative technologies under development in the Pervasive Computing research community are finding ample application in space.
- The Responsive Environments Group at the MIT Media Lab has been pivoting its Ubicomp projects into space applications.
- The group has had opportunities to run experiments on periodic zero-G parabolic flights, suborbital rockets, the Space Station, and even on the Lunar Surface.
- This work has increased the interest in the Pervasive Community toward space applications.



Projects presented in this article.



Smart textiles for space Can be woven into spacecraft structures to detect damage from debris impacts.

Tail linkage

Deployed with active pneumatics during 0–G test flight





Peristaltic Suit layout Prevent health problems astronauts experience in microgravity

AstroAnt MicroRover

Bottom view showing thermal sensor, space-qualified motors, and magnetic wheels







Projects presented in this article.



SpaceSkin strips

Conceptual layout for SpaceSkin strips

Space Shoe Active magnetic outsole in prep







TESSARAE test tile Conceptual interior of an assembled structure depicting several Space Initiative Projects

AstroAnt MicroRover Customized set with diverse sensing, diagnostic and servicing capabilities.





4

Outline of Projects



AstroAnt

Extra vehicle sensor network Equipped with **magnetic wheels** Modified with different sensor payload



SpaceTouch

Astronauts will vividly feel touch and texture through walls of pressurized suits.

Opposing tactile actuators



TESSARAE

Self-assembling space infrastructure. Individual tiles can be assembled into a variety of shapes. **Rigid-flex PCB**



Mediated Atmospheres In Space

Automatically adapt the sensorial environments of long-term space-farers to keep them focused and restored.

Biometric monitors Ambient light sensors







Outline of Projects



Peristaltic Suit

Wearable telemedicine system **ECG monitors** for heart activity **Accelerometers** for movement analysis Blood pressure sensors to assess physiological responses.



SpaceShoe

Intelligent dynamic foot restraint

Allows astronauts to walk on ferromagnetic surfaces.

Hall effect sensors

Pressure sensors



Electronic Textiles, Wearable Systems, and Surface Diagnostics Incorporates fabric walls on spacecraft Utilizing sensors like **piezoelectric sensors** to detect impacts, **thermal sensors** for temperature change monitoring



SpaceHuman

A controllable appendage designed for dynamic hands-free grappling in space. featuring sensors: gyroscopes and accelerometers for precise motion detection and control





Further More

Pervasive computing concepts and technologies can be applied to space exploration. Dating back to the 1960s, **spacesuits** served as precursors to **wearable computers**, pioneering the **monitoring** and control **capabilities** later echoed in **wearable systems** and **smart apparel** on Earth. These concepts resurfaced as fundamental elements of Pervasive Computing decades later.

7

Sensor Networks in Extreme Environments





1.

3.

2.

4.

Key features of the Lunar WSN include:

Sensor Nodes

Ballistic Deployment

Localization and Communication

Measurement and Analysis

5. Resource-Intensive Habitats

Hardware Redundancy















Virtual and Augmented Reality in Space **Mission Operations**









Smart Habitat Adaptation in Space Missions





Tidmarsh Portal

Mediated Atmospheres





Conclusions

- space exploration.
- and exploration.

1. New Space Age Opportunities: Testing and deploying ground-breaking ideas in

2. Technological Influence on Space farers: Impact of UbiComp/Pervasive/IoT on perception, cognition, and identity. Integration with AI and advanced technologies reshaping astronaut profiles.

3. Pervasive Computing in Space: Opening new pathways for space implementation



