Paper ID: 80362
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IAF HUMAN SPACEFLIGHT SYMPOSIUM (B3)
Human and Robotic Partnerships in Exploration - Joint session of the IAF Human Spaceflight and IAF Exploration Symposia (6-A5.3)

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EMOTIONALLY INTELLIGENT ROBOTS: ADVANCEMENTS IN SOCIAL AND COGNITIVE COMPUTING TOWARDS IMPROVING HUMAN-ROBOT INTERACTION IN SPACE

Abstract

With several upcoming long-duration crewed space missions, robots that have emotional intelligence capabilities are becoming increasingly critical in supporting the well-being and performance of astronauts.

Long-duration space missions subject astronauts to the effects of isolation, confinement, and exposure to extreme environments, which could take a toll on their mental health and affect crew cohesion. Emotionally-intelligent robots can mitigate these physical and psychological stresses, with social and cognitive computing (SCC) advancements providing promising avenues for achieving improved human-robot interaction (HRI) in space. For example, the social space robot Crew Interactive Mobile Companion (CIMON) uses SCC techniques to facilitate natural language communication in order to interpret voice commands, understand context, and respond appropriately to astronauts.

SCC techniques already play a significant role in influencing emotionally-intelligent robots on Earth. SCC involves analyzing social behaviors and interactions to help artificial intelligence (AI) systems recognise emotional cues, and uses machine learning (ML) algorithms and natural language processing (NLP) to understand the context of emotional expressions in order to respond appropriately. When applied to space settings, emotionally-intelligent robots have the potential to provide emotional support, companionship and cognitive simulation to astronauts, as well as better support crew interactions, decision-making and assistance in carrying out missions. Emotionally-intelligent robots on Earth that use underlying SCC techniques have shown to provide comfort and companionship, mental stimulation, possess the ability to support decision-making and even reduce pain perception.

However, there is not much research around emotionally-intelligent robots in space or the computing techniques behind them, with most research on HRI in space exploration covering the engineering aspects. This paper reviews existing social robots designed for space such as CIMON and Astronaut Assistant Robot (AAR), covering their emotional intelligence capabilities, and strengths and limitations towards meeting psychological challenges in long-duration space missions.

The paper will also review current advancements in social robots and SCC techniques such as NLP, generative language models, sentiment analysis, speech recognition, social signal processing (SSP) and discuss their applicability to improving HRI in space. Finally, the paper will recommend key areas of opportunity and research towards realizing emotionally-intelligent robotic capabilities for long-duration space missions.