Evaluation of Artificial Neural Tissues for Small Multirobot Networks in Handling Emergencies Onboard Next-Generation Space Stations

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Rapid advances in mobile computation, miniature low-cost sensors, actuators, and power systems are making a transformative impact on next-generation terrestrial buildings and facilities. Imagine every brick in a home can think, sense, plan, and predict, actively looking out for dangers, including toxins, fire, and smoke, facilitating efficient heating and cooling, and providing timely and precise info about components about to fail.  Such capabilities applied to the world of aerospace could offload the day-to-day operational challenges on next-generation space stations like the Lunar Gateway or a lunar surface base.  Conditions on the lunar surface and lunar orbit are challenging, as it is the dangers of solar flares, micrometeorites, intense temperature swings, and lunar surface dust.  We propose a system of system solution called SMART that would utilize a decentralized pocket cloud capability that computationally powers a network of smart sensors and small robots to perform dull, dirty, and dangerous tasks. The proposed robots would perform routine patrols, cleaning, repairs, and asset management tasks.  The computational backbone can allow for utilizing complex physical models to forecast and make optimal decisions with incomplete and even imprecise sensor data.

The system’s computational backbone is hyper-redundant and is being designed for handling all types of dull routine tasks, in addition to emergencies where human occupants may become trapped and be mentally impeded/shocked due to fast-changing outcomes.  In this presentation, we explore the potential applications, including the use of advanced machine learning and AI techniques called Artificial Neural Tissue to make efficient, even optimal decisions. In this presentation, we show how a network of robots learns to fight fire efficiently and, through this process, learn to evolve novel cooperative behaviors.  This approach will remain as a comparison to human-programmed approaches to tackle the same challenges.  With the machine learning approach, we hope to learn creative solutions to solve multi-robot decision-making tasks. We have also a developing a novel facility to test the system of system interplay (comparable to war-gaming), which will be shown in the presentation. Through these experiments, we hope to determine the overall feasibility of using a team of agile small fire and emergency handling robots for use on space stations and lunar habitats.  The applications of this technology could also have implications for a human Mars mission and human habitats in Cislunar space.