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AUTOMATED DESIGN OF ROBOTS FOR EXPLORING EXTREME ENVIRONMENTS OF MARS FOLLOWING AN ANIMAL SURVIVALIST APPROACH

Abstract

The discovery of living organisms under extreme environmental conditions of pressure, temperature, and chemical composition on Earth has opened up the possibility of existence and persistence of life in extreme environment pockets across the solar system including planets such as Mars. Subterranean ecosystem on Earth have remained isolated but have thrived for millions of years. Exploring such environments on Mars can ascertain the range of conditions that can support life and can also identify planetary processes that are responsible for generating and sustaining habitable worlds.

Over the last few decades, numerous missions started with flyby spacecraft, followed by orbiting satellites and missions with orbiter/lander capabilities. Since then, there have been numerous missions that have utilized rovers of ever-increasing size and complexity, equipped with state-of-the-art laboratories on wheels. Although, current generations of rovers have performed exceptionally well, but they are designed for predefined tasks and are not suited for exploring the extreme environment pockets of the solar system. In this work, we propose to use machine learning methods to design robotic platforms end to end that are better suited for exploring extreme environments. Our methods shows new notions of mobility, that combine hopping and running, that are better adapted to the low gravity, rugged surface environments. These procedures result in creative ideas that may not have been thought by human designers.

Current design methods use engineering experience and judgement of a team of experts to identify candidate designs. This process requires significant expertise and experience and is long and expensive in terms of time and labor. The lack of a systematic approach to fully evaluate the whole design space might lead to a sub-optimal solution or worse an intractable solution. Machine learning techniques however benefit from the exponential rise in computational speed and can overcome human team limitations, including number of experts available, time available to perform a design task, and time available to meet together and work continuously. We have applied these principles to design rovers suited for rugged environments, walking/hopping robots for low-gravity environments and hopping/rolling robots to explore underground environments like caves, pits and lava tubes. Our approach can evolve next generation exploration platform that seek to survive in an alien environment much like individual animals and operate for long duration. What better way is there to seek out life on planets like Mars by advancing animal survival strategies to utilizing local resources and shelters.