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Author: Ms. Valentina Lo Gatto
The University of Bristol, United Kingdom, valentina.logatto@bristol.ac.uk

A SOFT, BIOINSPIRED SWIMMING SPACE PROBE: A MISSION CONCEPT FOR THE EXPLORATION OF THE OUTER SOLAR SYSTEM'S OCEAN WORLDS.

Abstract

Robotics has played a vital role in space exploration since the beginning of the space era, in complementing and supporting human space missions but particularly in substituting humans wherever manned missions are deemed unfeasible. The search for life beyond our home planet is one of the key drivers for many ongoing and future space missions. However, a mission to ascertain life in the outer solar system will only be possible through the use of advanced robotics systems possessing high levels of adaptability, autonomy, reliability, and robustness as their main features. Therefore, the advance of robotic systems in the space sector is of crucial importance, in particular, the pursuing of those features which are highly desirable in deep planetary explorations missions. These features, however, are often found in living systems - plants and animals. Through millions of years, nature has employed an incredible set of engineering principles to develop solutions to evolve and survive, with soft tissues of the body and the emergent behaviors they generate from their interaction with the surrounding environment often playing an essential part in this process. In recent years, drawing inspiration from nature has become an increasingly appreciated approach in robotics. This research area, known as Bioinspiration, focuses on the study of natural organisms to extract their working principles, thus generating innovative solutions to unsolved engineering design problems. Although very few results have been achieved yet in terms of realistic applications to systems operating in the harsh space environment, there seems to be an increasing interest in applying this methodology to space for the great benefits that it might bring to space systems design. This paper's main aim is to present this approach for an innovative mission concept for the exploration of extraterrestrial marine environments: a soft, bioinspired, space probe able to swim its way through an unknown environment with an energy-efficient locomotion pattern. The suggested use of soft materials would provide two additional benefits fundamental for a space system: reduction in weight and higher deformability. Moreover, control schemes and behavioral architectures could be developed through Morphological Computation: intelligence embedded in the body such that behaviors emerge from the interaction of the physical body with the environment. The advantages and limitations of this approach are discussed as well as future perspectives.