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CRAWLERS, ARTIFICIAL MUSCLES AND A SECOND SKIN: ENHANCING HUMAN-ROBOT PARTNERSHIPS THROUGH SMART POLYMER COMPOSITES

Abstract

The debate around human vs. robotic exploration of outer space has evolved from the simplistic dichotomy of either-or to one of synergy whereby advances in intelligent, automonous robotics could actually enhance and lay the groundwork for further human space exploration.

This paper details the latest advances in the field of smart polymer composites, specifically electroresponsive polymer composites, and their potential to enhance human-robot interactions. The first generation of electroactive polymers (EAPs) were considered for space applications this past decade, notably as dust wipers on planetary rovers,end-effectors for soft robotics and adjustable apertures for telescopes. However, the EAP technology at the time was not mature enough for full space qualification and attempts to integrate EAPs into space robotics were aborted.

15 years later, there have been transformational strides in EAP actuators with the advent of new techniques such as nancomposite manufacture and electrospinning. Of particular interest and excitement to the space robotics community is the recent advances in seamlessly integrating polymer-based piezoresponsive wires into the EAPs, thus allowing for sophisticated tactile and force feedback, much like muscle spindles in biological muscles.

This has not only led to commercialisation of EAPs in various earth-based applications, but once again, opened up exciting applications in space robotics.

This paper will describe three scenarios, backed by data, of EAP-based robotic technology enhancing human exploration.

(a) Microcrawlers as robotic precursors on treachorous terrain: Here we use gel-based EAP composites to build a worm-like robot to effectuate motion on uneven terrain through cyclic expansion and contraction. The large surface area allows for integration of polymer-based strain and biochemical sensors to capture and relay information back to the human explorer.

(b) Soft, adaptable grippers and end-effectors: In this case, EAP-based actuators are integrated into a robotic hand or an astronaut glove for the sensing and manipulation of small, fragile objects during space exploration or construction.

(c) Wearable Robotic Interfaces: As an extension of (b), we design a wearable interface consisting of both electroresponsive polymers and phase-change thermal materials to provide for secondary thermoregulation and adaptive counterpressure, as well as to enhance the sensory, and load-bearing capabilities of the astronaut.

All the above scenarios will be described with relevant data and working prototypes. It is hoped that these examples would kickstart a much broader discussion on the vast potential of the (new and improved) EAP composites as robotic partners for the next generation of human space explorers.