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DESIGN CONCEPTS AND IMPLEMENTATION OF THE LIGHTWEIGHT ADVANCED ROBOTIC ARM DEMONSTRATOR (LARAD)

Abstract

Beyond the current ExoMars programme, the European Space Agency (ESA) is investigating a range of technology developments and exploration mission opportunities leading to a future Mars Sample Return Mission (MSR), a critical next in the exploration of Mars. To fulfil their scientific objectives, all of these missions require an arm with a long reach capable of performing a variety of tasks in stringent environmental conditions, such as low gravity sampling and precise sample handling and insertion.

As part of a CREST-2 project supported by the UK Space Agency (UKSA), a consortium of UK companies have co-founded and developed LARAD, a new Lightweight Advanced Robotic Arm Demonstrator

to address some of the underlying challenges related both to the design as well as operation of long arms to perform the payload deployment and sample return operations of future missions.

The 15kg terrestrial demonstrator is built as a 2m long arm with 6 degrees of freedom. This arm is capable of deploying a payload with a mass up to 6kgs or operating a 4kg end-effector at 2m. It is using cutting edge technologies on both the hardware and software levels. The mechanical structure of the arm has been manufactured using an array of new processes such as optimised 3D printed titanium Additive Layer Manufactured (ALM) joints, Titanium/Silicon carbide metallic composites, and 3D printed harness routing drums.

A modular joint design has been produced, featuring three mechanical sizes of joints each with integrated low level communication and motor drive. The electronics, software and sensors used in the joints are common across all sizes, increasing modularity.

To achieve precise positioning, very high resolution absolute position sensing is used on-board. The arm uses novel collision avoidance and path-planning strategies combined with classical control loops. The On-board Control System's state machine combines different control strategies/modes (i.e. joint trajectory tracking, direct motor control, autonomous placement) depending on the high level user operation requirements. The high level On Board Computer (OBC) is Robot Operating System (ROS) based, enabling a flexible software approach.

This project will provide a unique and representative platform to plan and rehearse science operations with full mass payload and instruments, unlike typical planetary arm developments that require scaled-mass end-effector.

This paper describes the current state-of-the-art in planetary robotics and provides an overview of the top-level architecture, implementation and laboratory testing phases for the LARAD robotic arm.