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Editorial on Space Robotics Papers

Editorial

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1. Introduction

Over the past few months a suite of six papers have or are being published on Space Robotics in the International Journal of Advanced Robotic Systems. Space represents the most varied of hostile environments, be it in interplanetary space or planetary environments. It is also the most challenging by virtue of its extreme remoteness. All but one paper was concerned with manipulator-based systems in space – the one exception concerned robotic drilling into planetary surfaces. The paucity of rover-based papers was surprising but probably represents a selection effect. Early pioneering research in space robotics began in the 1980s with the Shuttle Canadarm but continues to flourish today as evidenced by the continuing work in this field. Another curious fact is that all the papers originated in China, illustrating that China is joining the community of spacefaring nations with vigour. Furthermore, Chinese engineers are developing their own approaches to space robotics. The core concept in space robotics is the notion of one or more manipulators mounted onto a spacecraft bus designed for satellite servicing (typically) – this represents a complex multi-body system to be controlled. Although an independent spacecraft attitude controller may be employed to stabilize the manipulator mounting platform, the free-floating system employs only joints to control the dynamics of the system.

The paper "Repetitive motion planning of free-floating space manipulators" by Chen G et al. considers free-floating robotic systems with a spacecraft mounted manipulator: a set of optimization operators are presented to ensure that the space-based manipulator is returned to its original pose at the end of a motion task to enable repetitive motions. This exploits the redundancy in the system to apply constraints and overcome some of the problems of free-floating systems, namely, their nonholonomy. The paper "Subsection evolution in GA for trajectory planning of space manipulator" by Zeng C et al. considers optimal trajectory segments by introducing a genetic algorithm to evolve polynomial coefficients subject to the constraints of kinetic energy minimization. This is a variation on the well-known use of genetic algorithms as a learning rule in neural networks. The paper "Fault tolerant attitude control for flexible satellite with uncertainties and actuator saturation" by Meng Q et al. introduces consideration of flexibility into multi-body space robots: a model-based computed torque controller for flexible appendages is presented that is robust to dynamic flexibility uncertainties. Flexibility is a characteristic of space manipulators due to the severe constraints on structural mass. The paper "A generalised visual aid system for teleoperation applied to satellite servicing" by Zhang G & Jiang Z considers teleoperation issues for robotic satellite servicing: it describes a visual system based on predictive

3D virtual modelling graphics to generate errors between the real and virtual robot for real-time visual servoing. The paper "Mechanism design and system control for humanoid space robot movements using a simple gravity-compensation system" by Jiang Z et al. considers an experimental apparatus to simulate a humanoid robotic astronaut prototype: it simulates zero-gravity through gravity-compensation by flexible chains, a ball screw mechanism and a fine-tuning mechanism. This considers a newer application of space robotics, the humanoid robot, the most well-known example being the US Robonaut. The final paper "Measuring tape-like sampling arm and drill for sampling lunar regolith" by Lu W et al. introduces a novel type of lunar drill which uses a vibrating head and a curved cross section metal tape for its deployment. Planetary exploration is of course a significant application of space robotics with a gamut of relevant robotic devices – manipulators, rovers, aerobots, moles, drills, sample processing and distribution, and even submersibles (for Enceladus, for instance). Of course, these papers represent only a small snapshot of space robotics activity, but this snapshot sample indicates that it is active and innovative.