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Modelling, identification and control of a flexible lightweight robot for space applications

Luca Bascetta, Gianni Ferretti, Federico Fossati, Gianantonio Magnani, Andrea Rusconi, Bruno Scaglioni

In the last two decades there was an increasing interest of robotic researchers towards the development of anthropomorphic robots for space exploration, capable of autonomously performing various and complicated operations even in the presence of high load ratios. Famous examples are the DLR lightweight robot[1] and the Instrument Deployment Device[2] installed on the NASA Mars exploration rover.

A lightweight anthropomorphic robot -- {DELIAN} (DExterous LIghtweight ANthropomorphic arm) -- is also currently under design by Selex ES S.p.A. within the ESA Mars Robotic Exploration Preparation (MREP) programme. The main tasks {DELIAN} is expected to accomplish are the deployment of tools in conditions of microgravity, the deployment of tools, such as video cameras, on the ground of the planet Mars, in conditions of Martian gravity, the collection of geological samples from the Martian soil and their deployment inside a rover.

In this paper, a preliminary analysis of the joints of a robot for space applications is introduced, aimed at evaluating the effectiveness and stability of the position control loop and the influence of disturbing effects, such as gravity and friction. In this respect, a main issue must be addressed, namely the modelling of the link flexibility, which plays a fundamental role in determining the static and dynamic behaviour of the positioning system.

A model and an experimental characterization of the transmission chain is presented, together with a model of the distributed flexibility of the links based on the floating frame of reference technique. A simulation analysis of the behaviour and performance of the position control loop completes the paper.

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[1] A. Albu-Schaffer, S. Haddadin, C. Ott, A. Stemmer, T. Wimbock, and G. Hirzinger, "The DLR lightweight robot: design and control concepts for robots in human environments," Industrial Robot: An International Journal, Vol. 34, No. 5, 2007, pp. 376–385, 10.1108/01439910710774386.

[2] E. Baumgartner, R. Bonitz, J. Melko, L. Shiraishi, and P. Leger, "The Mars Exploration Rover instrument positioning system," Aerospace Conference, 2005 IEEE, March 2005, pp. 1–19.