Topology optimization of hyper-redundant modular robotic manipulator

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ABSTRACT

This study deals with topology optimization of spatial robotic manipulator, the geometry of which was proposed initially in [1]. The manipulator consists of serially connected modules in a form of a cylinder cut at a certain angle at its ends. The manipulator constructed in this way allows for relative rotation of adjacent modules, which gives one degree of freedom per module. The operation of overall robotic system resembles the elephant trunk manipulator. Previous research involved the possible kinematic transformations of the manipulator [2], but not its structural optimization [3]. However, structural design of the involved modules is a challenging task, as the process has to take into account the current configuration of the module along the manipulator, which results in variable internal force. It leads to optimization problem under multiple loading conditions with a significantly large number of loads. This study considers optimal topology of such a modular manipulator structure. Due to the large variety of possible load conditions, the initial analysis involves a 3D model of the structure with a continuous set of possible arrangements of individual modules. An additional constraint imposed on the solution will take into account the symmetry of the optimal topology of a single module, which is dictated by manufacturing considerations.

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