

Topology Optimization of Planar Linkage Systems having Various Joint Types

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Abstract

The problem we consider is to investigate if planar linkage systems having various joint types beyond revolute joints can be synthesized by the topology optimization method. Handling with various joints would be critical if a linkage mechanism is to be practically useful. While earlier related investigations were concerned with revolute joints, we are considering prismatic joints and complex joints besides revolute joints during the synthesis of planar linkage mechanisms. Because it is difficult to deal with various joint types with the nonlinear-bar ground model, as used in some earlier researches, we are employing a spring-connected rigid block model, which can simulate a rigid linkage mechanism with these various joints. In this study, we propose a new method to determine proper joints among the above-mentioned joints as well as mechanism layouts as the result of our topology optimization based linkage mechanism synthesis algorithm. The key idea is to develop new spring connectivity models between a block and its adjacent blocks and also between a block and the ground. Meanwhile, the objective function of the synthesis problem is transmittance efficiency which is known to effectively control the degrees-of-freedom while the target path of the end-effector is treated as constraint equations. To be able to solve general problems, the process of the synthesis is performed by using the MMA, a gradient-based algorithm. Some path-generation benchmark problems were solved to verify the validity and effectiveness of the proposed method. The problems solved were four-bar linkages such as a slider crank, inverted slider cranks, etc. Because of the highly-nonlinear characteristics of the present design problem, there could be multiple optimal solutions satisfying the required constraints. As a result, some interesting linkage mechanisms were also obtained during the study of this investigation, which may open an eye of a designer to new types of mechanisms.