An Automated Reconfiguration Sequence Process of a Bar-Linkage Structure

Maria MATHEOU*, Ibrahim CHAMSEDDINE[a,b], Michael KOKKOLARAS[a], Marios C. PHOCAS

* Department of Architecture, University of Cyprus,
Kallipoleos St. 75, 1678 Nicosia, Cyprus
matheou.maria@ucy.ac.cy

[a] Department of Mechanical Engineering, McGill University,
817 Sherbrooke St. West, Montreal, Quebec H3A 0C3, Canada

[b] Department of Integrated Mathematical Oncology, H. Lee
Moffitt Cancer Center and Research Institute, 12902 USF
Magnolia Drive, Tampa, FL, 33612 USA

Abstract

Transformable architectural structures have variable geometrical and mechanical properties in order to adapt to changing external functional, environmental, or loading conditions. Rigid bar structures can undergo shape transformations through mechanical actuators at the joints. The number of integrated actuators should, however, be limited due to the associated weight increase and design complexity. We consider a principal planar arch-like frame consisting of a 9-bar linkage and one actuated joint. In principle, the reconfiguration approach applied is based on the 'effective 4-bar' concept, using a sequence of one degree-of-freedom motion steps by selectively releasing four joints of the primary members at a time and engaging brakes installed on each individual joint and one geared electrical motor at the base. Different intermediate configurations depend on the motion planning, in order to adjust the system's joints to the desired values during the motion steps involved from the initial to the target position. Recent studies of the reconfigurable structure were associated with simulation analyses and experimental testing of a prototype in scale 1:5. The results obtained here from provided an insight to the mechanical design and reconfiguration approach. In following, an automated reconfiguration sequence process is proposed. The initial and target configuration for the planar system are defined on the basis of a quasi-ellipsoid shape of 5.42 and 4.49 m height respectively and 4.66 m span. The numerical studies have been conducted with the software MATLAB and Simulink for a Model Based-Design. All geometrical, mass and inertia characteristics of the planar 9-bar linkage are exported through the dynamic analysis software program Solidworks Essentials and implemented in the algorithmic model as blocks. A closed feedback loop reads all different motion patterns of the locked and unlocked joint angles for each step, while at the same time the simulation model in Simulink is updated automatically. The obtained results demonstrate that the design of reconfigurable structures can benefit from an automated analysis of possible sequences, from the initial to the target position, further enabling respective optimization tasks in achieving better performance and efficiency.

Keywords

Reconfigurable structures, Motion planning, Reconfiguration sequence, Adaptive direct search algorithm.