Towards compliant and structural optimization of a Compliant Rotation Reducer Mechanism (Sim-AM 2019)

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ABSTRACT

Within a multitude of domains, the advances of topology optimization are coming closer in reach due to progress in additive manufacturing and considering its ability to tackle a vast array of target problem definitions simultaneously has received significant attention in compliant mechanism design [1].
This paper shows the application of topology optimization for both compliant and structural elements to a custom designed mechanism for a project of the European Space Agency. More specifically it concerns a compliant rotation reducer mechanism as shown in Figure 1a. This work is a benchmark to see to what extent improvements can be obtained with the presented hybrid approach on which a pre-design is sub-structured into a set of compliant and structural optimization problems, compared to an ongoing classical design approach.
The problem is broken down from an innovative pre-design of a compliant mechanism into subproblems consisting of a set of rigid bodies V_s and a single volume V_c on which a compliant topology optimization is performed, shown in Figure 1b.

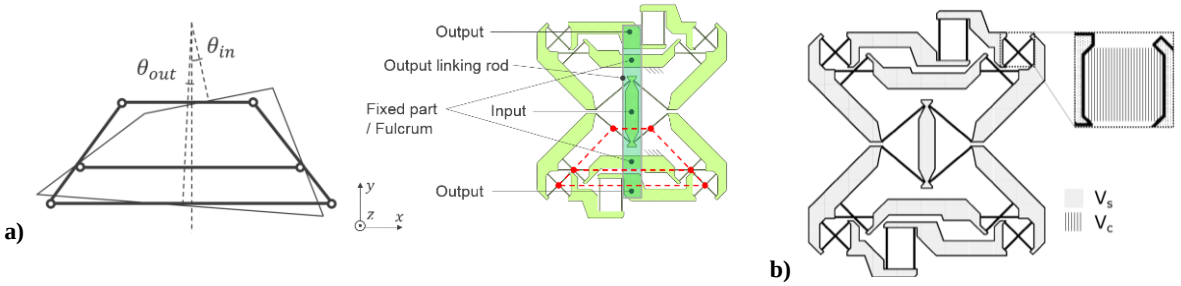

Figure 1: a) The compliant reducer mechanism pre-design and its functionality, b) The definition of the structural topology optimization volume V_s, and the compliant optimization volume V_c.

The structural part of the optimization was performed with the use of Altair Optistruct using the default solver. In which the different structural volumes had respective manufacturing constraints taking into account overhang, symmetry and extrusion constraints to ease interfacing with the compliant structures and manufacturing. After which smoothing was performed using Polynurbs in Altair Inspire. The optimization result in an optimized parasitic vibration mode from originally 400 Hz to 1000 Hz. This enables a more resistant mechanism for launch in space applications.
Though the mechanism comprises several different compliant mechanism sub-problems, we focus on an optimization problem of a simple pivot shown in Figure 1b. The problem definition here consists of: (1) an element that is compliant in rotation ± 5 Degrees, (2) has minimal parasitic shift, (3) maintains good off-axis stiffness and (4) keeps the stresses low enough to minimize fatigue and improve the mechanism lifetime, while taking into account (5) overhang constraints. Here we study and compare the performances of the generated pivot to the classical one while increasingly adding the constraints as mentioned above. Here we built upon the framework initially developed by [2]. Though challenging the first results show promising solutions.
In conclusion, this paper presents a hybrid approach seeking to improve an existing design by decomposing it into several simpler optimization problems for structural and compliant mechanism optimization. Future developments will focus on advancing the optimization by going towards a single compliant mechanism optimization that could replace the entire flexible and rigid structure.

REFERENCES

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