

Surrogate model of elastic large-deformation behaviors of compliant mechanism using co-rotational beam element

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In this study, we propose a surrogate model for predicting nonlinear structural deformations of elastic flexural mechanisms. Pseudo-rigid-body model is often used for describing the behaviors of a structure, such as compliant mechanism, with deformation degrees-of-freedom (DOF) as a combination of rigid bars and torsion springs [1]. However, it is necessary to construct a computational model based on the geometrical shape of each structure by trial and error.

In accordance with Ref. [2], by using co-rotational beam element, we develop a generalized surrogate model, which can predict nonlinear responses of a compliant mechanism with the essential deformation DOF of beam element without any geometrical assumption. The total number of DOFs of nodes at both ends of a two-dimensional beam is six, while the number of deformation DOFs is three, i.e., axial extension, symmetric bending, and anti-symmetric bending. Therefore, it enables us to reduce the computational cost, from 6×6 to 3×3 , associated with the models by using the essential deformation DOFs of the co-rotational beam element.

It is difficult to predict the nonlinear responses of forces derived from displacements of a compliant mechanism represented by a co-rotational beam element. The reason is that a single forced-displacement simulation can produce multi-stable states due to the geometrical nonlinearities and numerical instabilities. To overcome this problem, we generate the data sets by applying external forces and use its inverse response for training the surrogate model.

In the numerical examples, large-deformation behaviors of several types of compliant mechanisms are predicted by the proposed model. The accuracies of the prediction are investigated for verifying that it can be a beneficial tool for designing structures with nonlinear elastic deformation behaviors.

REFERENCES

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