

Low-rank and sparse approximations for contact mechanics

Typical strategies for reducing the computational cost of contact mechanics use low-rank approximations. The underlying hypothesis is the existence of a low-dimensional subspace for the displacement field and a low-dimensional subcone for the contact pressure. However, the contact pressure exhibits a local nature, as the contact position can vary with parameters like loading or geometry.

The adequacy of low-rank approximations for contact mechanics is studied and alternative routes based on sparse regression techniques are explored. It is shown that the local nature of contact pressure leads to a loss in linear separability, thereby limiting the accuracy of low-rank methods

Subsequently, approximations using over-complete dictionaries containing a large number of snapshots to mitigate the inseparability issues is investigated. Two strategies are devised using sparse approximation methods. One is based on an active-set approach where the dictionary elements are selected greedily, and another is based on convex hull approximations where the non-penetration constraints need not be explicitly enforced.

Lastly, the non-linear dimensionality reduction framework is explored. The snapshot set computed in the training phase is enriched at a low complexity using non-linear interpolations, thereby reducing the burden of creating over-complete dictionaries in the offline phase.

Mots-clés : Model Order Reduction, Low-rank approximations, contact mechanics, dictionary-based approximation, non-linear dimensionality reduction