Interval Model of Equilibrium Equations in Statics

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Abstract

Statics is an essential prerequisite for many branches of engineering, such as mechanical, civil, aeronautical, bioengineering, robotics, and others that address the various consequences of forces. Societal concerns have led to more stringent requirements for the safety and reliability of products; they demand new methods for validation, verification, and the quantification of uncertainties.

We consider equilibrium equations that are used in statics, e.g., equilibrium equations of the forces and the momenta. It is assumed that each parameter involved in these equations has uncertain magnitude which varies within given compact interval. The goal is to provide an interval model which is consistent with the physical interpretation of the corresponding equations and yields the best interval estimation for the involved unknown parameters. This is a challenging task since the classical interval arithmetic does not posses group properties and, therefore, it is not suitable for modeling interval equilibrium equations.

We present a simple interval model combined with efficient computational procedure, based on the algebraic properties of the complete algebraic structure of proper and improper intervals. Various examples will illustrate the application of the proposed methodology. The potential for further applications that deliver more realistic interval estimations will be presented together with the ability of interval analysis to account for the parameter uncertainties and for the interval dependencies from the very beginning of the modeling process preserving full consistency with the deterministic model.