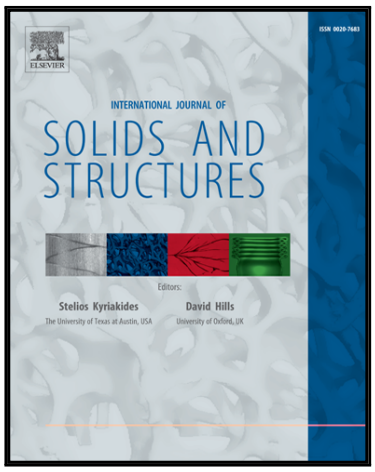

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Polarities in structural analysis and design: *n*-dimensional graphic statics and structural transformations

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Abstract

This paper proposes a unified and entirely geometrical methodology for generating 2D and 3D force diagrams for given planar and spatial trusses in static equilibrium within the context of graphic statics. The trusses, regarded as form diagrams, are projections of higher dimensional simply-connected stress functions, can be either self—stressed or loaded with external forces, and need not be tension-only/ compression-only. First, we provide an in-depth overview of fundamental notions of graphic statics and projective geometry related to the construction of reciprocal form and force diagrams. Specifically, we describe a series of polar transformations and discuss them from a geometric and an algebraic standpoint. Moreover, we provide an exegesis and visualization of Maxwell's reciprocal methods while discussing them within the scientific framework of his time. We then develop a contemporary graphic statics framework grounded on projective geometry and higher-dimensional reciprocal stress functions. Within this framework, we provide a general methodology for deriving any type of reciprocal diagrams for the planar and the spatial case. Advantages of this method include: direct control on any of the four reciprocal objects (form diagram, force diagram, corresponding stress functions) and no need for iterative/ procedural reconstruction of any of the diagrams since it is based on direct geometrical transformations. Finally, we