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FORM-FINDING OF INTERLACED STRUCTURES

Seyed Sina Nabaei[1], Olivier Baverel[2] and Yves Weinand[3]

[1,3] Chaire of Timber Construction (IBOIS)
École Polytechnique Fédérale de Lausanne (EPFL)
CH-1015, Lausanne, Switzerland
e-mail: sina.nabaei@epfl.ch , yves.weinand@epfl.ch, http://ibois.epfl.ch/
[2] Navier research unit
École des Ponts ParisTech (ENPC)
Champes-Sur-Marne, France
e-mail: baverel@enpc.fr, Web page: http://navier.enpc.fr/

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By Interlaced Space Structures (ISS) we mean an actively bent structure consisted of a coupled system of interlaced flexible thin panels/stripes/strands, naturally curved from a flat initial state under the imposed position and rotation on their end nodes. Form-finding of an ISS can be regarded as solving a constrained system of coupled Elasticas with bending and torsional degrees of freedom. The design parameters for an ISS are the overlap pattern, the offset between panels at overlap and the coupling formulation, the position and orientation of fixed end nodes for each stripe, their initial length and finally their bending and torsional stiffness. The objective is to determine the curved relaxed form of the corresponding ISS in accordance with the pattern and the parameters set. We are looking for a physically-based quantitative but efficient form-finding procedure in order to interactively explore different interlaced morphologies for structural design purposes. Each panel is considered as an inextensible beam with an anisotropic cross section. We use an implementation of the Discrete Elastic Rod model [1] to simulate the stripes. The DER model for nonlinear flexible rod simulation is based on the curve-angle kinematics and has been efficiently used to deal with highly nonlinear problems such as physically based hair simulation. We reformulate the initially proposed DER nonlinear dynamic framework into a nonlinear static one since the relaxed final form is solely looked-for. The form-finding problem is regarded as a constrained total energy minimization, with the vector of released stripe vertices and unprescribed segment material frame angles as variables. Strip order and offset at overlap nodes and inextensibility of segments are the main constraint and variants such as identical orientation of thin panels at overlap are also discussed. We employ an implementation of the interior-point filter linesearch algorithm with the Quasi-Newton procedure to solve the constrained nonlinear optimization and discuss the results through a case study.

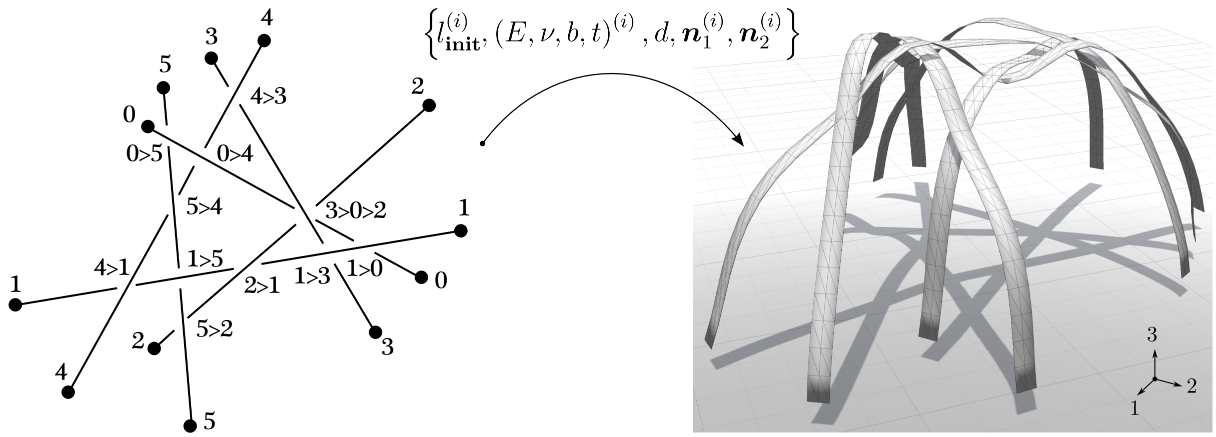

Figure 1: Graph representation of an ISS *(right)* with one of its dual structure *(left)*. Other dual variants might be obtained by changing the set of parameters $\left\{l^{(i)}_{\mathbf{init}}, (E,\nu,b,t)^{(i)}, d, \boldsymbol{n}_1^{(i)}, \boldsymbol{n}_2^{(i)}\right\}$ for each strand$^{(i)}$

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