An extended linear procedure for constrained form finding

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Abstract
The authors propose an extension of iterative application of force density method, originally used for form finding and internal force evaluation of tensile structures [1]. Improvements will be made in two directions i.e. accelerating computation in order to successfully implement this method into the interactive structural design tool, as well as enabling the user to influence the appearance of the final solution in a more efficient manner.

The initial method iteratively applies the linear force density method by recalculating force density coefficients using force and length values from the previous iteration step. Conveniently adapted coefficients lead the calculation towards the geometry which fulfils imposed force and/or length constraints [1, 2]. The goal is to preserve the linear procedure for constrained form finding, but reduce the number of iteration steps, and consequently execution time. Therefore, the accuracy for solving the system of linear equations is optimized in each iteration step [3]. Inspired by Inexact Newton method, the procedure gradually decreases the tolerance with which the linear systems are solved, from relatively loose initial tolerance (when force values or element lengths are far from the required ones) to specified tight tolerance which provides final equilibrium configuration. If tolerance for solving the system of equations is optimised, further acceleration can only be expected from the solver. Therefore the new solver based on the iterated Ritz method [4] is integrated into the extended algorithm. Besides for the acceleration of the method, the focus of the paper is on the ability to assign undeformed element lengths, in addition to force and length constraints from the initial setup of the algorithm. In that way, the demand for more possibilities to control the final geometry can be addressed. In the paper, the extended method is used for constrained form finding of spatial truss structures in either tension or compression. The performance of the extended procedure with and without the new solver is evaluated through various examples by comparing the number of iteration steps and execution time against the existing method.

References

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