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Optimization of origami folding patterns for metamaterials

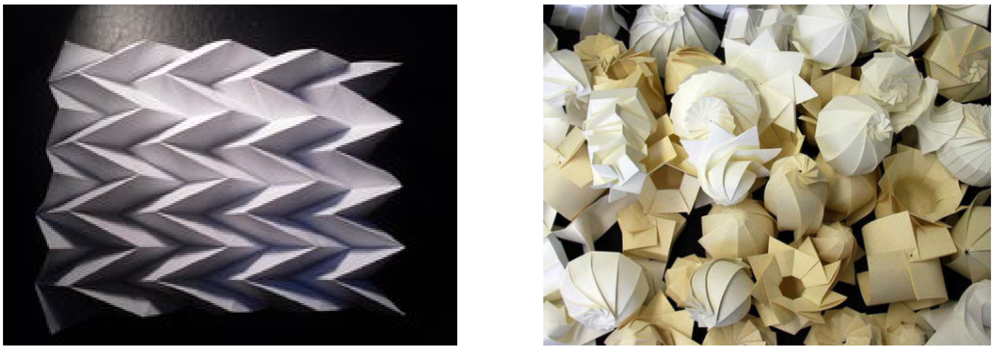
Master of Science project

Abstract

This M.Sc. project consists in the computational design and optimization of origami folding patterns. The student will implement advanced numerical methods for the optimization of folding patterns within hybrida, a rapidly growing in-house finite element library that is currently being developed at the Structural Optimization and Mechanics (SOM) group.

Introduction Contrary to natural materials, whose behavior is mainly determined by their composition, metamaterials obtain functionality that is not often seen in nature by means of the way they are structured at relatively small length scales. Metamaterials have tremendous potential as they broaden the spectrum of functionalities with new applications that not too long ago were undreamed of. Considering that metamaterials are created from a repeating building block structure, their design and creation present many significant challenges in precision and micro-systems engineering science. The realm of metamaterials has spread out from its origin in the field of electromagnetism, and regarding mechanical metamaterials alone, many new functionalities have been investigated, including energy absorption, acoustic/phononic wave propagation, heat conduction, and negative Poisson's ratio.

Figure 1a shows the Miura-Ori pattern, one of the most commonly suggested designs due to its simple shape. This pattern is considered a metamaterial because of its negative Poisson ratio and repeating structure. Figure 1b shows some closed origami structures designed by specialized software. The objective of this project is a thorough study of origami structures and their mechanical modeling in hybrida, our in-house finite element library. Furthermore, the objective is to find optimal configurations given an objective function, *e.g.*, compliance.



(a) (b)

Figure 1: Origami structures in paper: a) The Miura-Ori pattern; and b) Software-designed closed origami structures.

Tasks *i)* Conducting a thorough literature review on the different methodologies used in the modeling of origami metamaterials; *ii)* Implementing the code for the analysis of origami structures within hybrida; *iii)* Obtaining different design strategies by defining various objectives; *iv)* Manufacturing a prototype that achieves a target functionality; *v)* (If time permits) Include geometric non-linear analysis of the folded structure; *vi)* Presenting the results and preparing a report that could lead to a peer-reviewed journal publication.

Requirements The student should have modeling experience and basic knowledge of finite element analysis. Python programming experience is recommended.