Mechanical Engineering Master's Defense

Non-local Finite Element Model for Rigid Origami

School for Engineering of Matter, Transport and Energy

Deepakshyam Krishnaraju

Advisor: Dr. Hanqing Jiang

abstract

Origami is an art transforming flat sheet of paper into a sculpture. Amongst various types of origami, the focus was on a particular class called the 'Rigid Origami'. A Rigid Origami, unlike other forms, is not intended to be folded into fancy shapes. On the contrary, a Rigid Origami has simple and geometrically well-defined crease pattern, and does not have curved/smudged faces. The folds can be carried out by a continuous motion in which, at each step, each face of the Origami is completely flat. As a result, these planar faces experience very minimal strain due to loading. This property allows it to be used to fold surfaces made of rigid materials. Tapping into the geometrical properties of Rigid Origami will open a new field of research with great practical utility.

Analyzing each new Rigid Origami pattern will require generation of numerous prototypes; which practically impossible to do as it consumes a lot of time and material. The advantages of Finite element analysis/ numerical modeling become very lucid in this scenario. A new design concept may be modeled to determine its real world behavior under various load environments, and may therefore be refined prior to the creation of drawings, when changes are inexpensive.

A Rigid Origami undergoes a non-local deformation when subjected to a disturbance; the usage of conventional FEA will not produce accurate results. A non-local element model was developed; which can be used in conjunction with finite element package ABAQUS via its user-defined element (UEL). This model was tested on two Rigid Origami patterns, namely, Miura Ori and Ron Resch.

There are many other interesting Origami patterns, which exhibit different meta-material properties, and are yet to be explored. This finite element approach equips researchers with necessary tools to study them in great detail.

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