

Folded Shell Structures

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Introduction

Applying a *local* texture to thin-walled sheets may alter the *global* mechanical behaviour of the shell structure. In this research the effects of folded texture patterns are investigated, with the aim of creating morphing surfaces.

Analysis

The figure below shows a sheet of paper folded using the *Miura-ori* pattern. In planar deformation it has a negative Poisson's ratio, but during bending the sheet displays behaviour usually associated with a positive Poisson's ratio (*i.e.* a saddle shape). It is this intriguing, counterintuitive behaviour we sought to analyse.

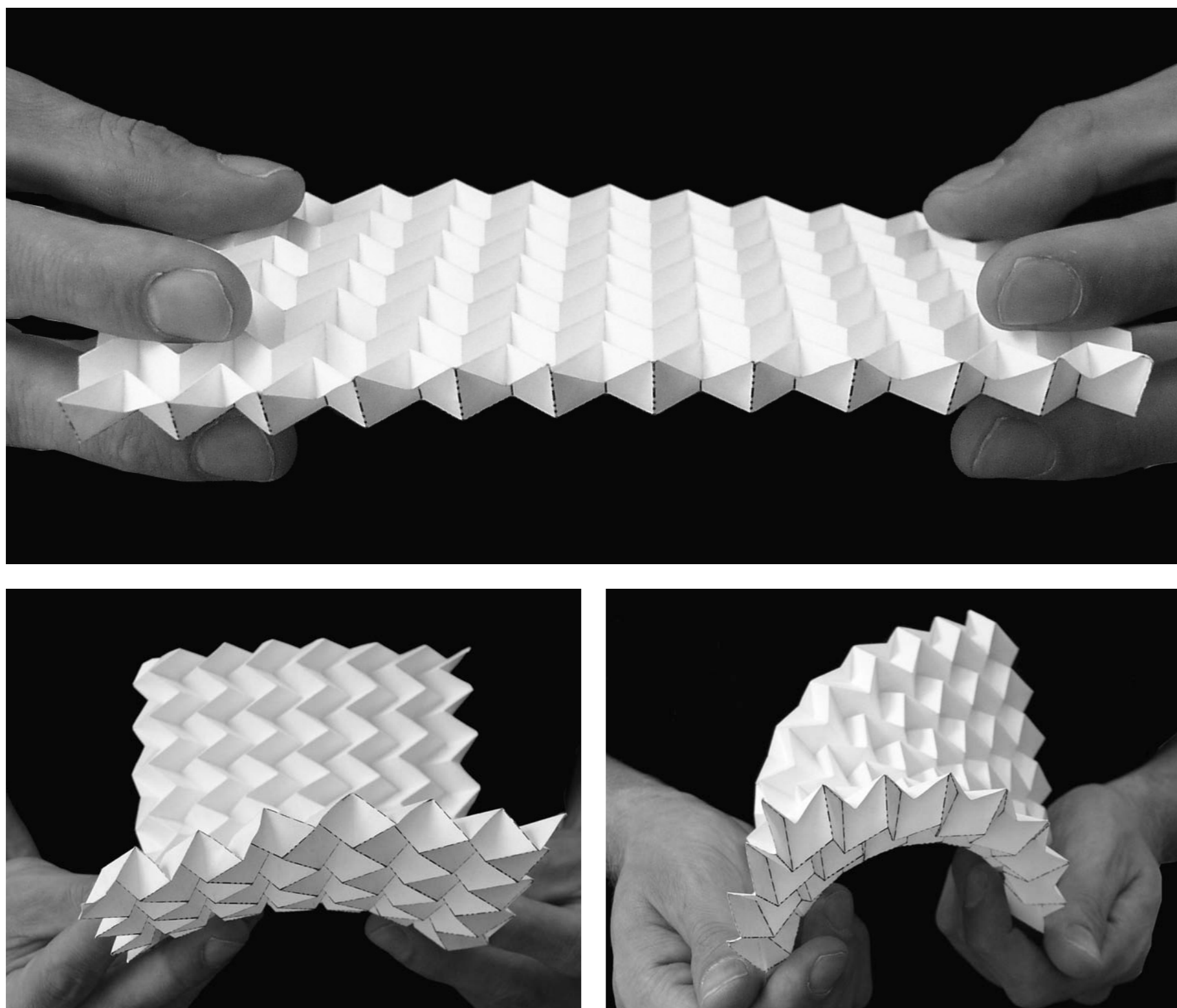


Figure 1 - under bending the Miura sheet deforms into a saddle shape.

The folded sheets are modelled as pin-jointed frameworks, with additional bending stiffness along the fold lines and across the facets. The softest eigenmodes of the associated tangent stiffness matrix provide insight in the global deformation kinematics of the sheet.

Results

When only allowing bending at the fold lines, the planar kinematics are obtained.

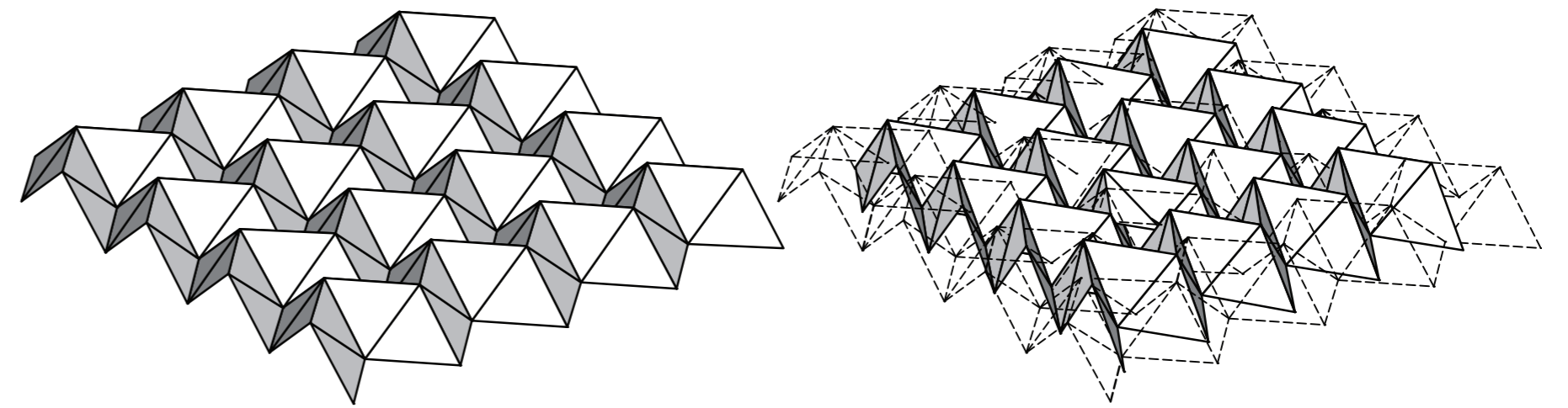


Figure 2 - the Miura sheet has a single planar mechanism.

Allowing the facets of the folded sheet to bend as well, provides the out-of-plane bending modes. The softest mode is a global twisting of the sheet; the second mode is the saddle-shape deformation observed when bending the paper models. This mode is drawn below; a mid-surface plane is added to illustrate the global shape of the sheet.

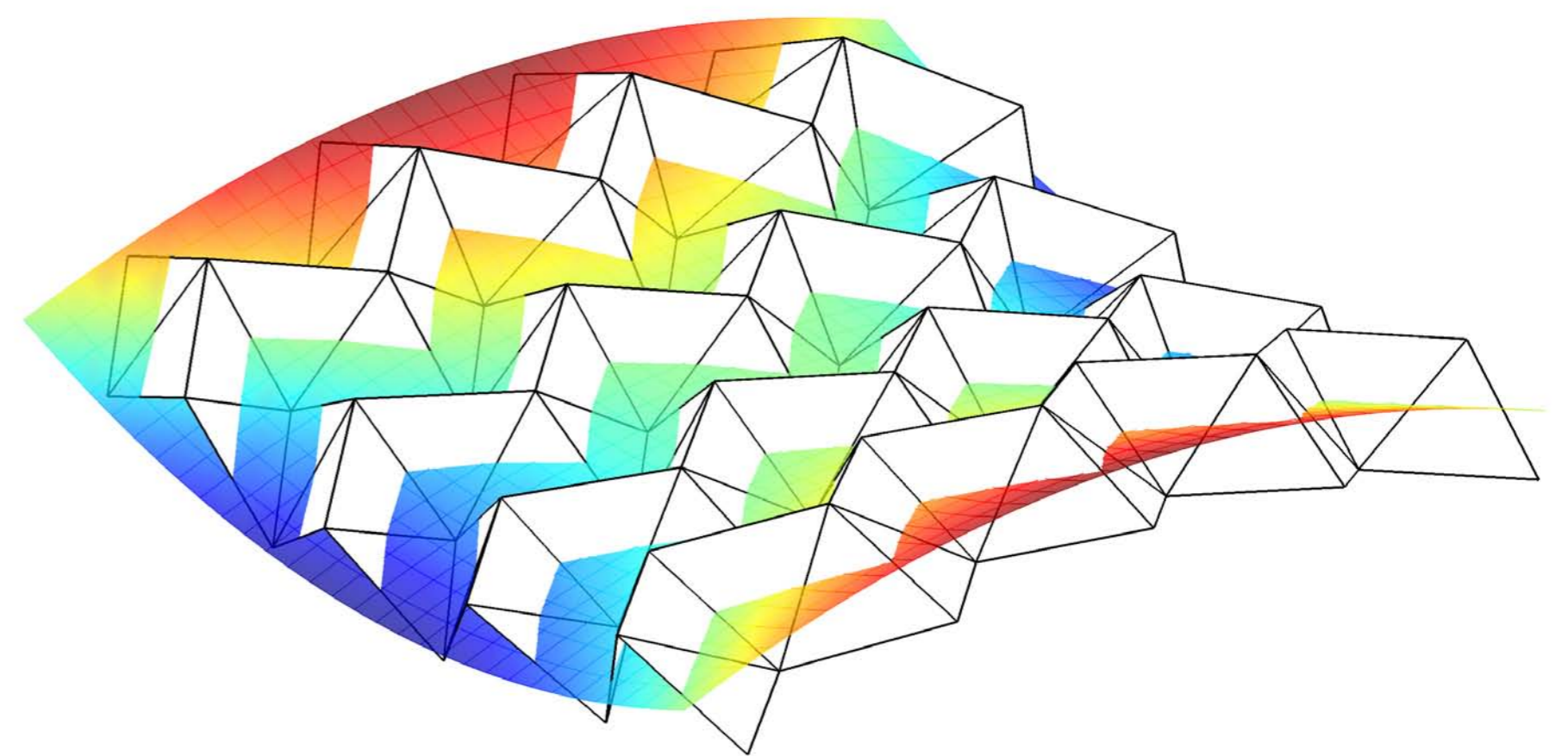


Figure 3 - saddle-shaped eigenmode of the Miura sheet.

Conclusions

Folded sheets display unique mechanical behaviour, such as an oppositely signed Poisson's ratio for bending and extension. Modelling the folded paper sheets as pin-jointed bar frameworks has allowed to capture qualitatively the global deformation modes.

Publications

Schenk, M. (2008), "*Textured Shell Structures*", first-year PhD report, University of Cambridge.