Computational Fabrication of Architectural Structures using Mechanical Metamaterials

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Computational Fabrication

It is the field of research that deals with limitations in the fabrication process of 3D objects:

- Overcoming geometric limitations;
- Overcoming material limitations;
- Speeding up the fabrication process;
- Reducing costs;
- …

[State of the Art on Stylized Fabrication, Pietroni et al. 2019]

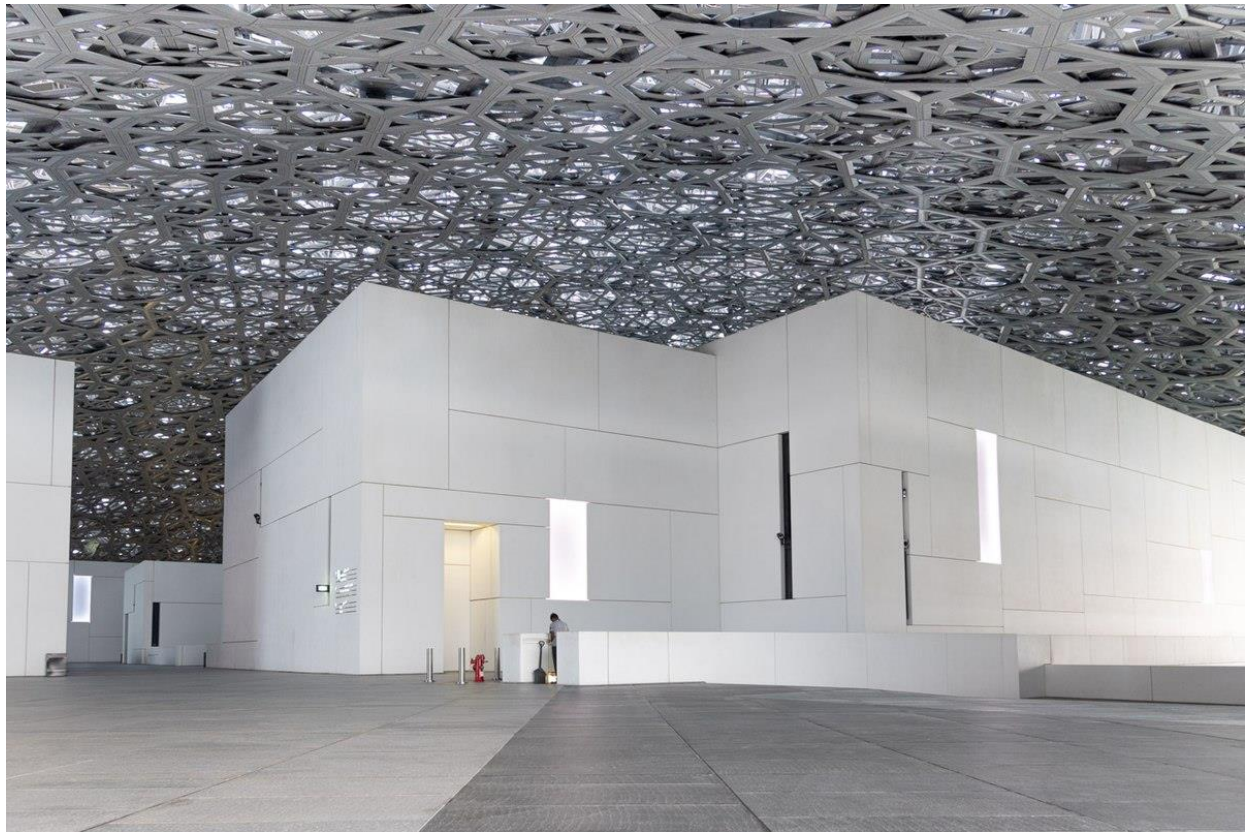
[Metamolds: computational design of silicone molds, Alderighi et al. 2018]

Freeforms in Architecture

Freeforms are mostly non-developable sufaces used to build massive structures. They need to be decomposed in smaller pieces in order to be manufactured.

Patterns in Architecture

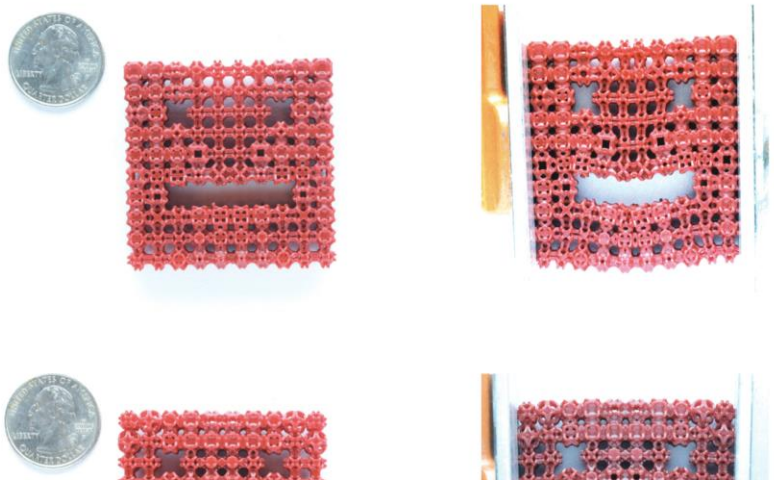
Patterns are used to achieve artistic goals, to decompose the target shape into simpler elements and/or to provide structural properties.

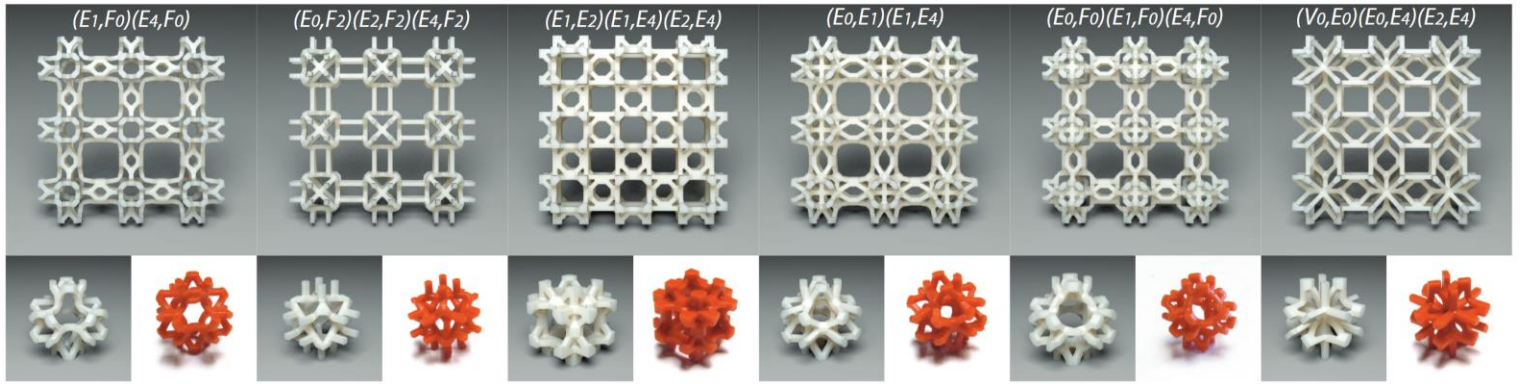


Mechanical Metamaterials

Metamaterials are structures whose properties are determined by the geometry of the structure. What kind of properties?

- Mechanical
- Optical
- Acoustic
- …

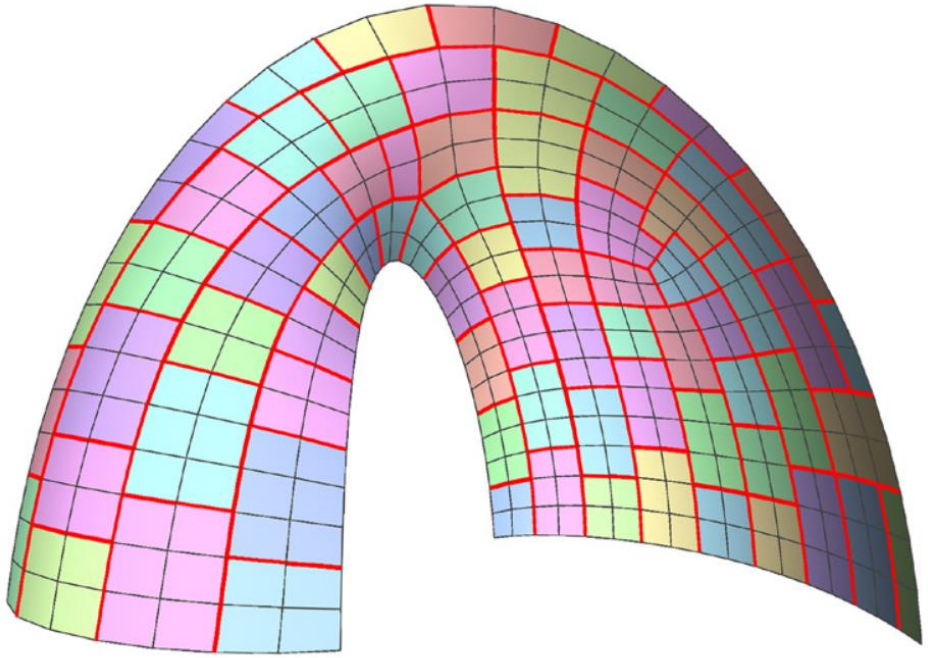


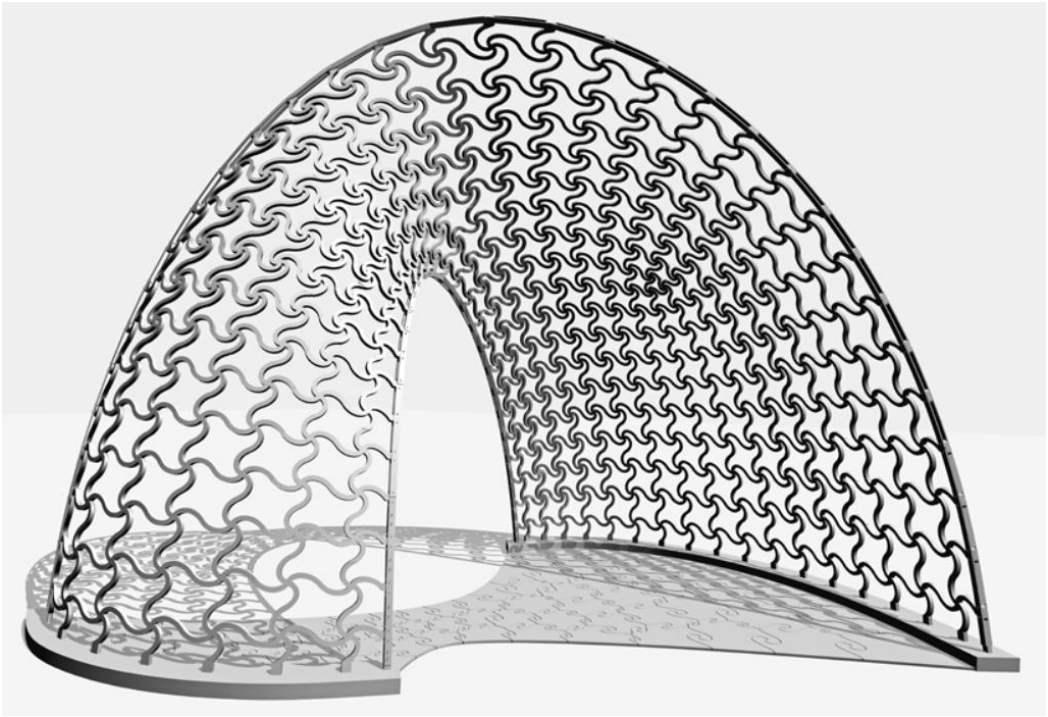


[Elastic textures for additive fabrication, Panetta et al. 2015]

Mechanical Metamaterials in Architecture

Mechanical Metamaterials can provide specific aesthetic style, while reducing costs and saving time in the manufacturing process.





[Design and construction of a bending-active plywood structure: the Flexmaps Pavilion, Laccone et al. 2020]

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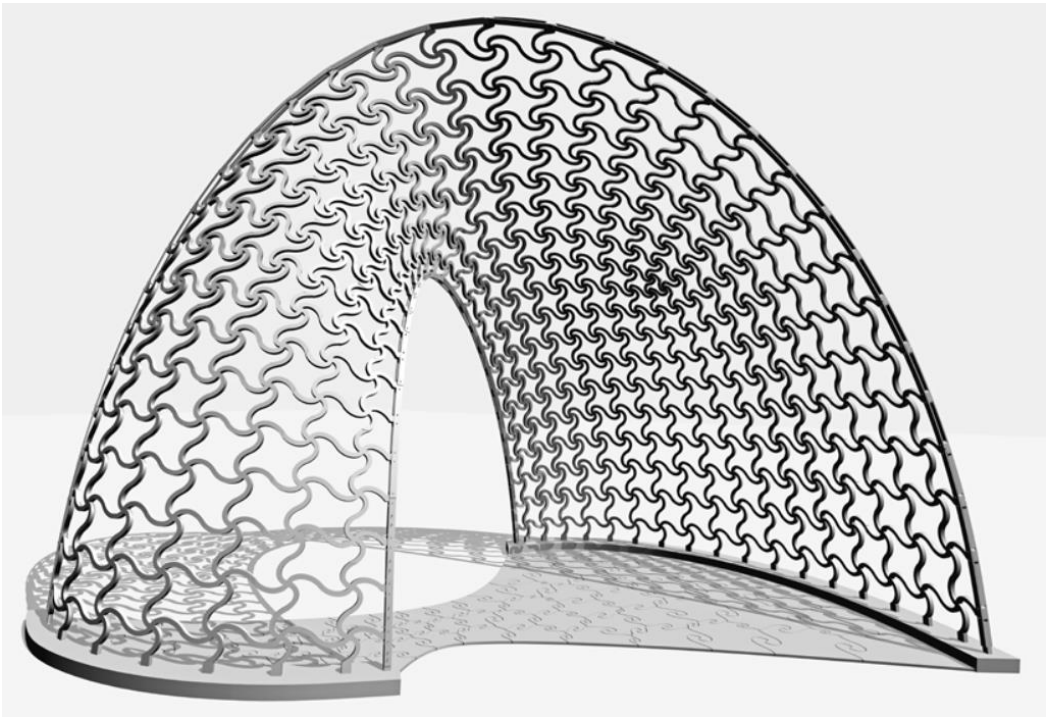

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The inverse design problem

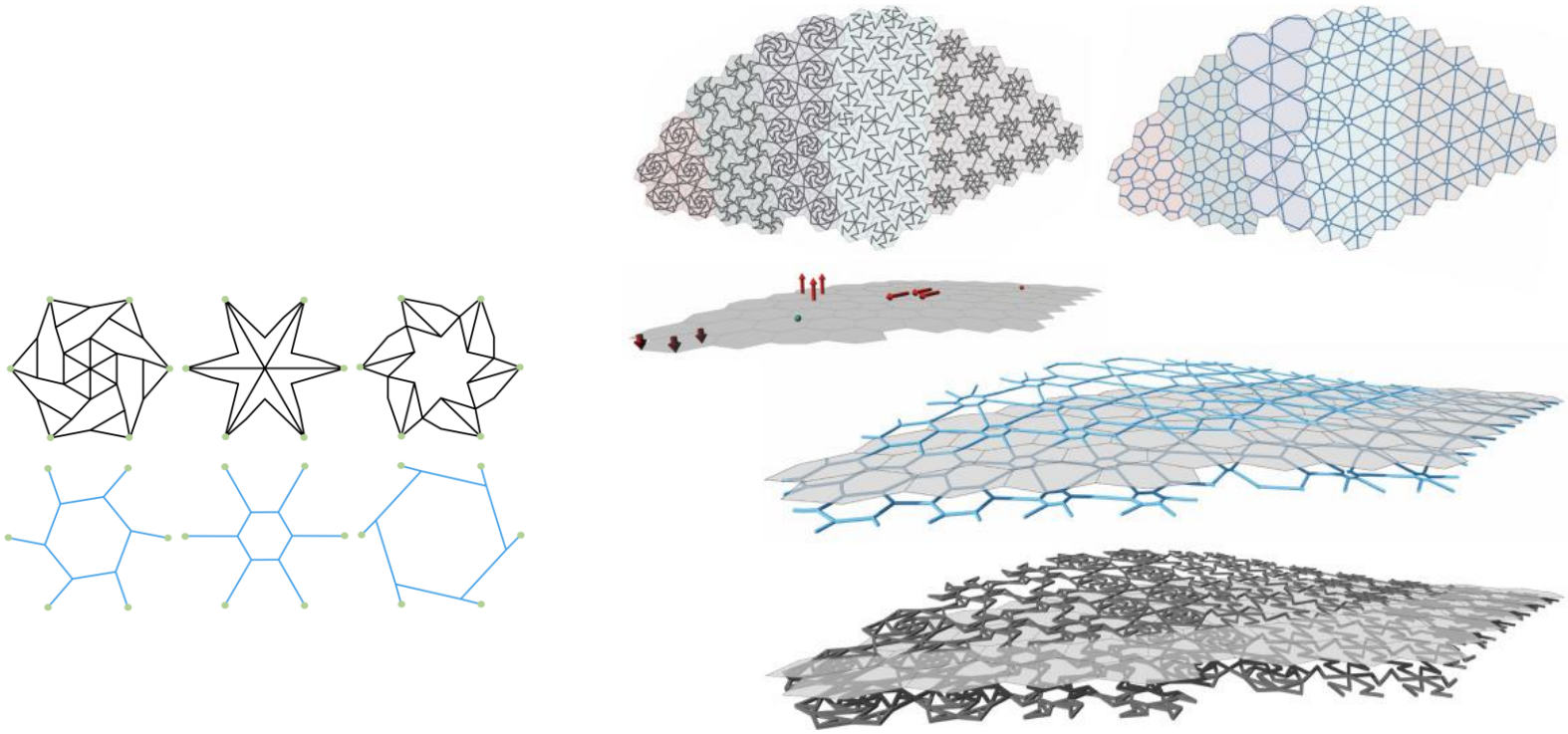
Given a target shape:

- How to define a proper family of metamaterials?
- What is the optimal way to combine them?

Reduced model

Simulating the mechanical response of geometrically complex structure is time consuming.

A *reduced model* of a mechanical metamaterial is a simpler geometric pattern that has the same mechanical properties.



[Automated generation of flat tileable patterns and 3D reduced model simulation; Manolas et al. 2022]

Thank you!

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Questions, curiosities and critical remarks are welcomed.

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