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Origami-inspired smart building skin

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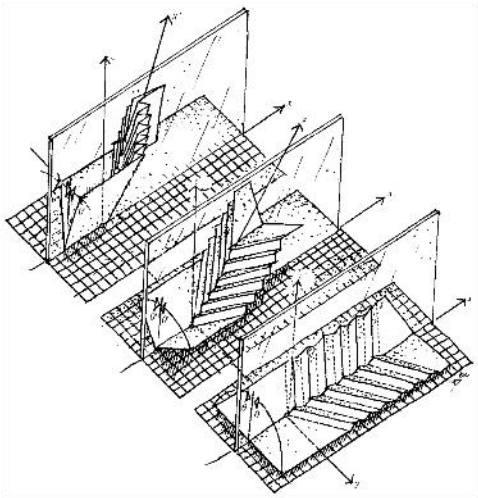
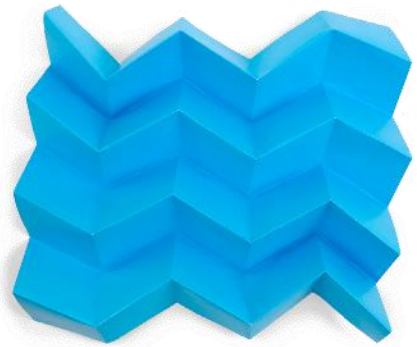
Concept Investigation





NATURE

Leaf of Carpinus Betulus (European Hornbeam)

GEOMETRICAL FEATURES

Geometrization of the folds of a Carpinus Betulus leaf

ORIGAMI

V-pleat Miura-Ori tessellation pattern derived from the leaf

KINETIC ARCHITECTURE

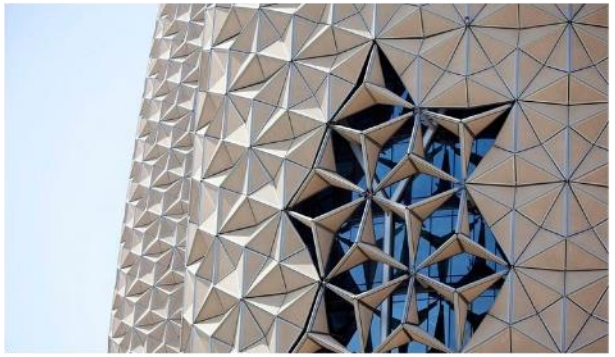
Concept for a self-organizing Origami structure, D. Lee

State of the Art Analysis









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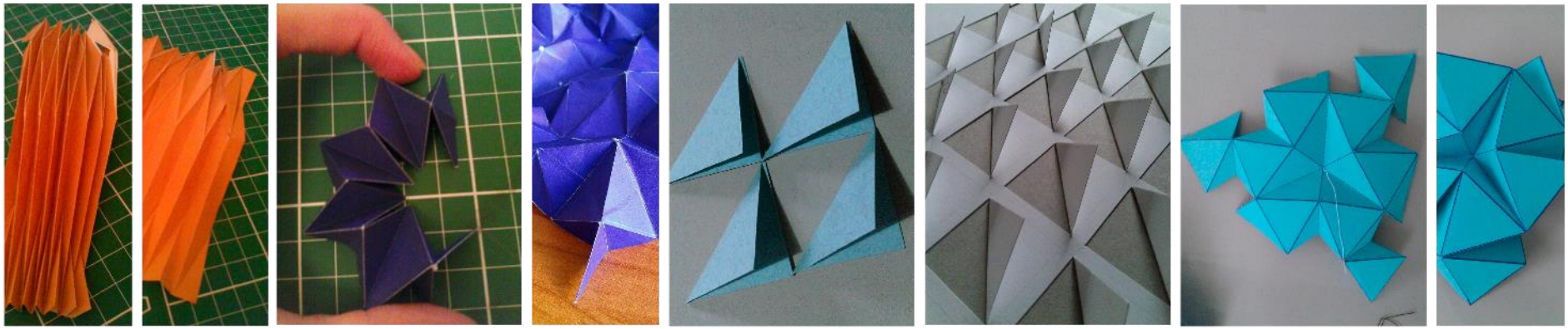
Concept Statement

> Conceptual design of a **PERFORMATIVE, ENVIRONMENT-RESPONSIVE**
> **ORIGAMI-INSPIRED MODULAR STRUCTURE**
> able to change its **DEGREE OF OPENNESS** by adjusting its spatial configuration in **RESPONSE TO ENVIRONMENTAL PARAMETERS VARIATIONS** (like lightning, noise and temperature), all recorded by a **NETWORK OF EMBEDDED MICRO-SENSORS**



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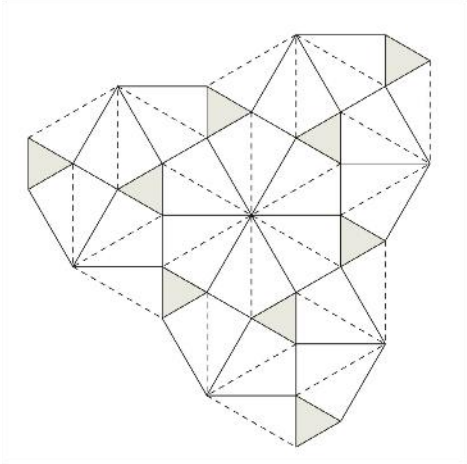
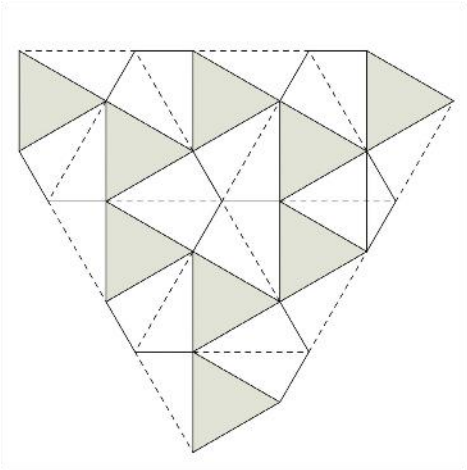
Geometry Definition



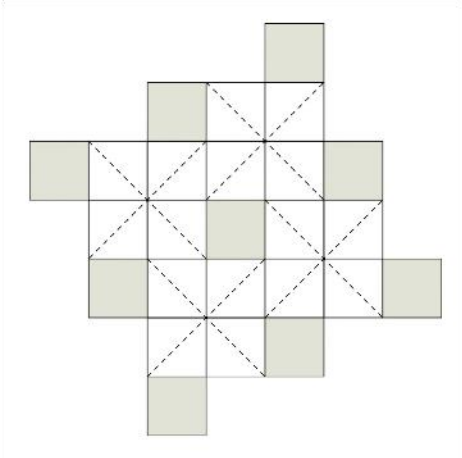
1_

HEXAGONAL
PATTERN



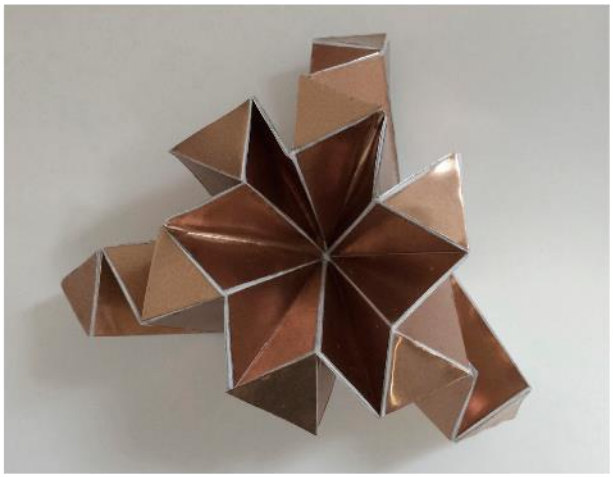
2_

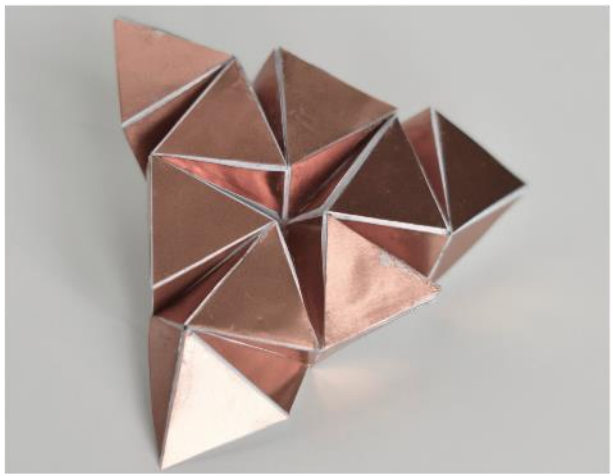
TRIANGULAR
PATTERN

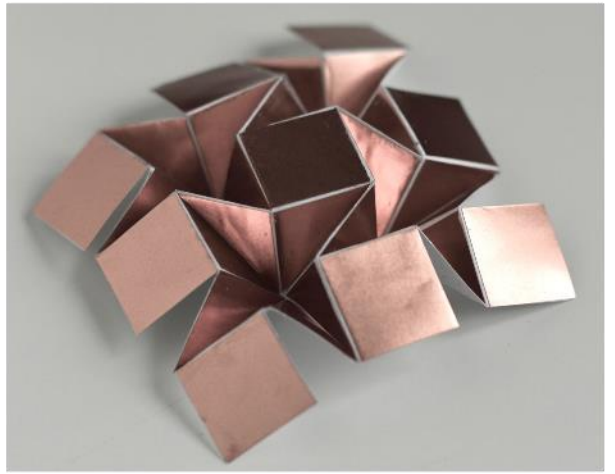


3_

SQUARED
PATTERN







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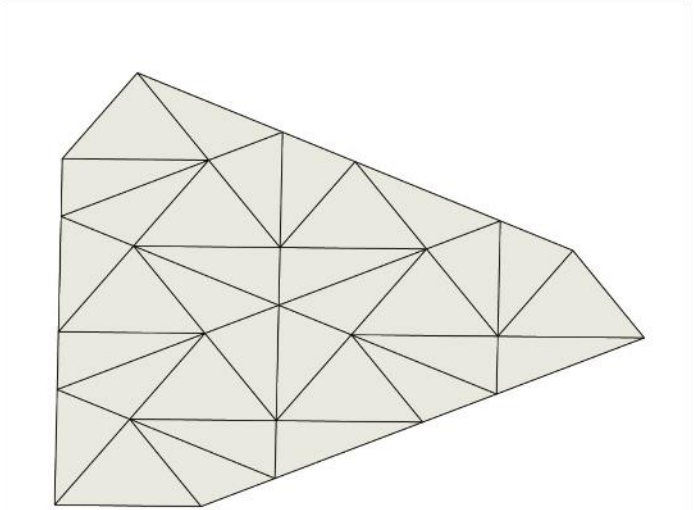
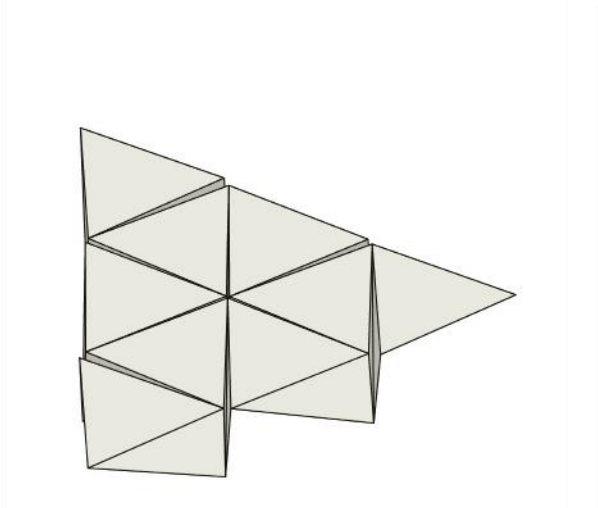
Configuration



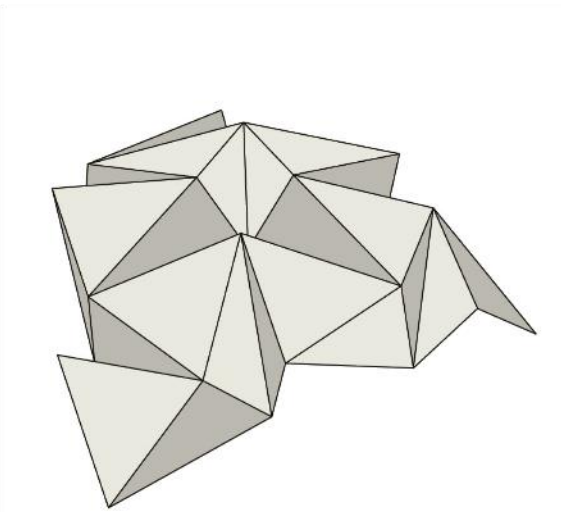
0_
step

FLAT POSITION,
OPEN ORIGAMI



1_
step

CLOSED MODULE



2_
step

DEPLOYED MODULE

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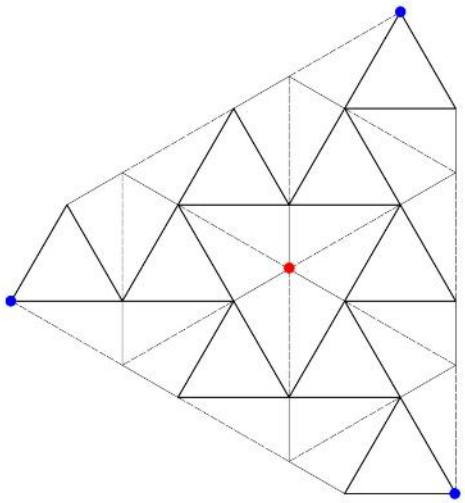
Kinematic Analysis

Model: zero thickness
Spring structure



1 DOF STRUCTURE

Z coordinate of the pivoting point

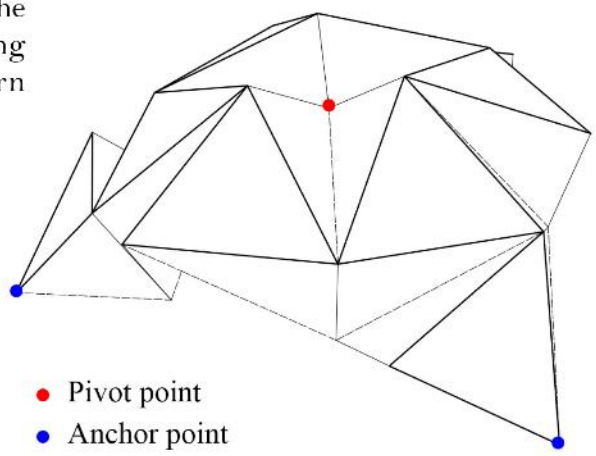
CONSTRAINTS

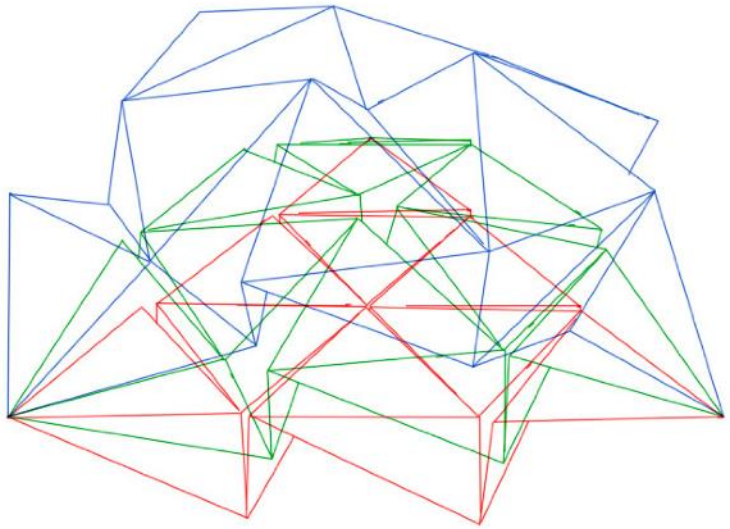
3 vertexes as hinges

SELF ADAPTIVITY

achieved through the movement of the pivoting point on Z axis

Position of the anchor and pivoting points on the pattern





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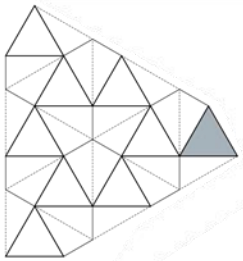
Physical Features

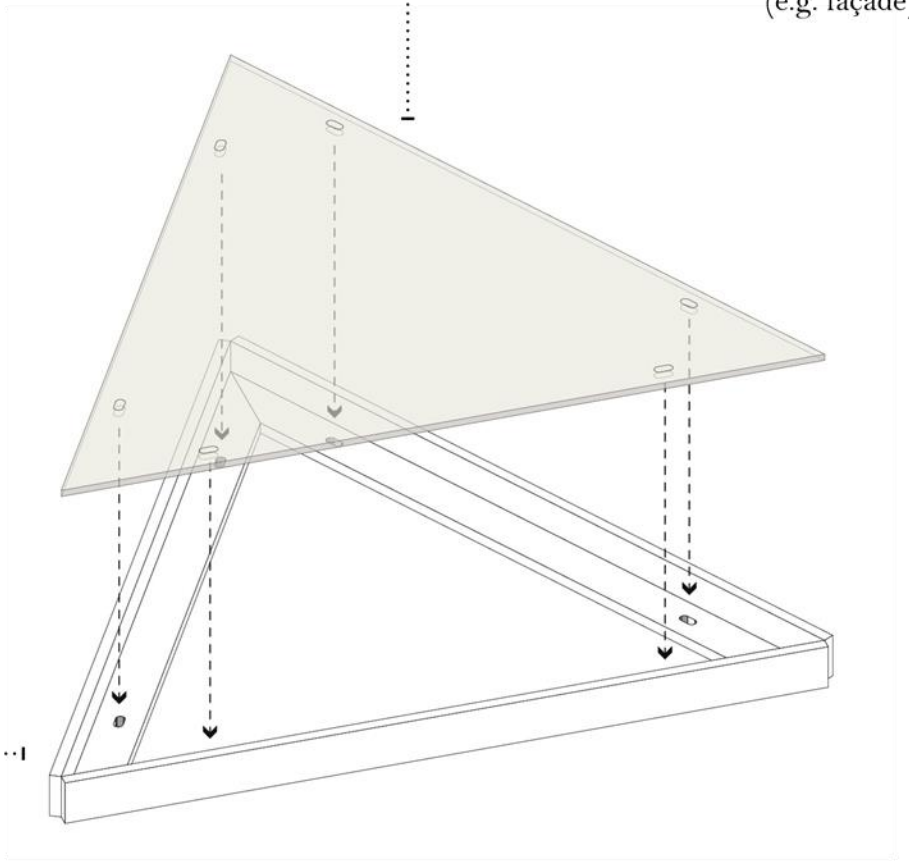
FRAME-PANEL SYSTEM

detail of one triangular module constituting the Origami surface



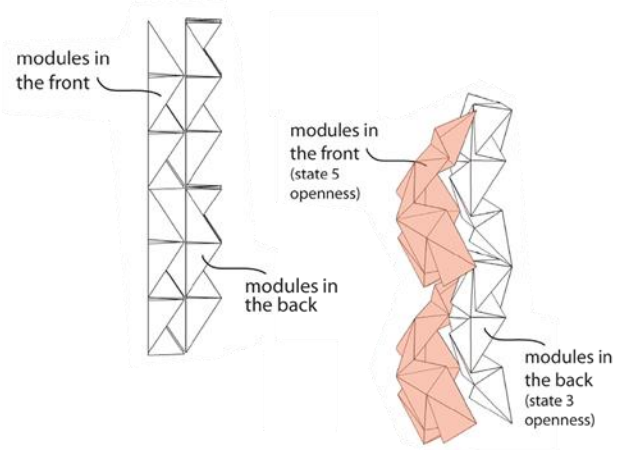
modular panel

modular frame

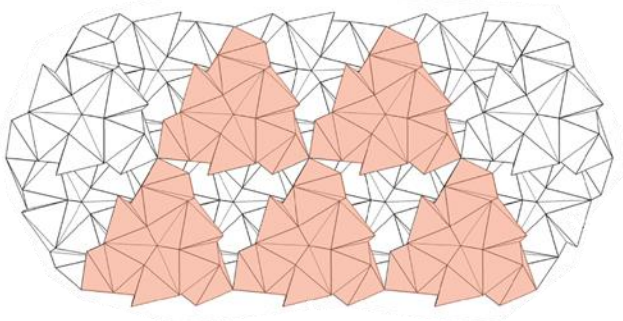


COMPOSITION

Composition of the Origami modules mounted on a surface (e.g. façade)

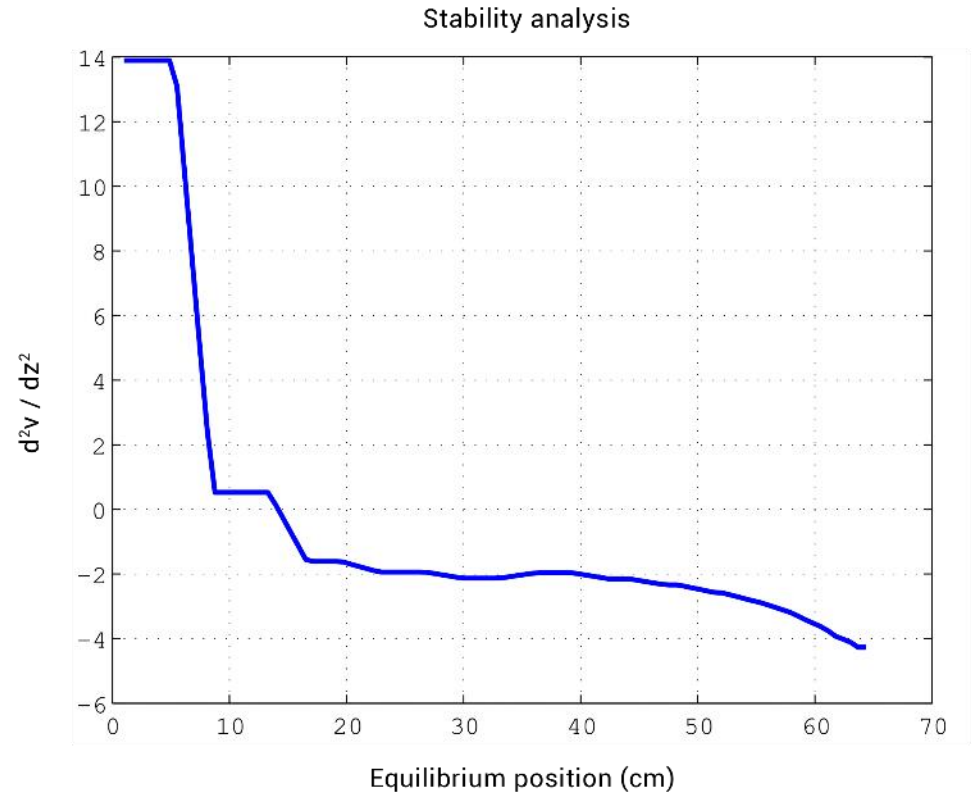


superposition technique, common support structure



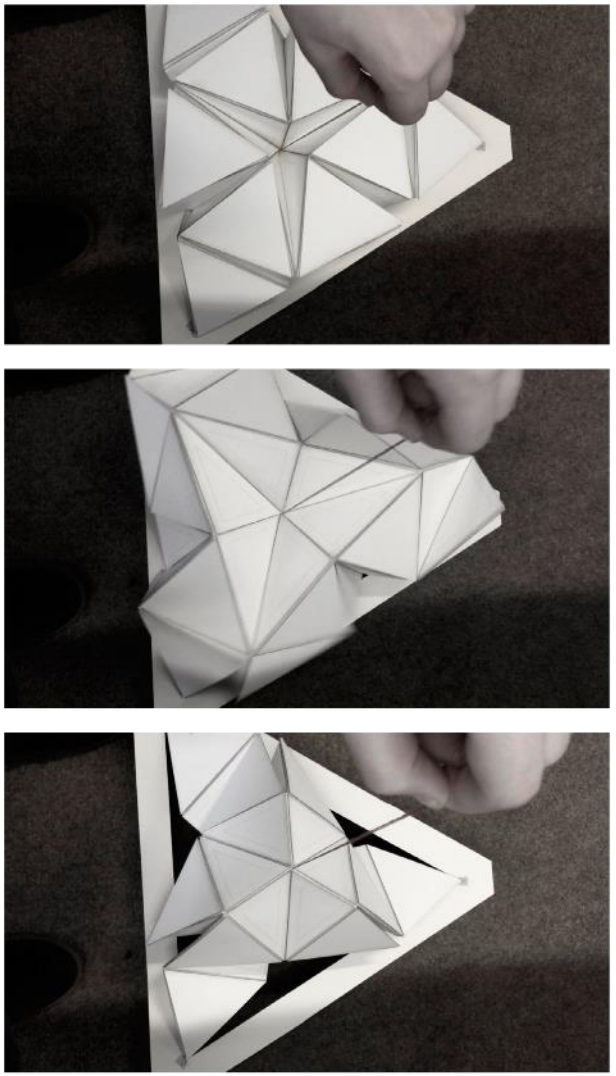
Stability Analysis

STABILITY ANALYSIS IN MATLAB



PHYSICAL TEST-MODEL

Deployment analysis, manual actuation



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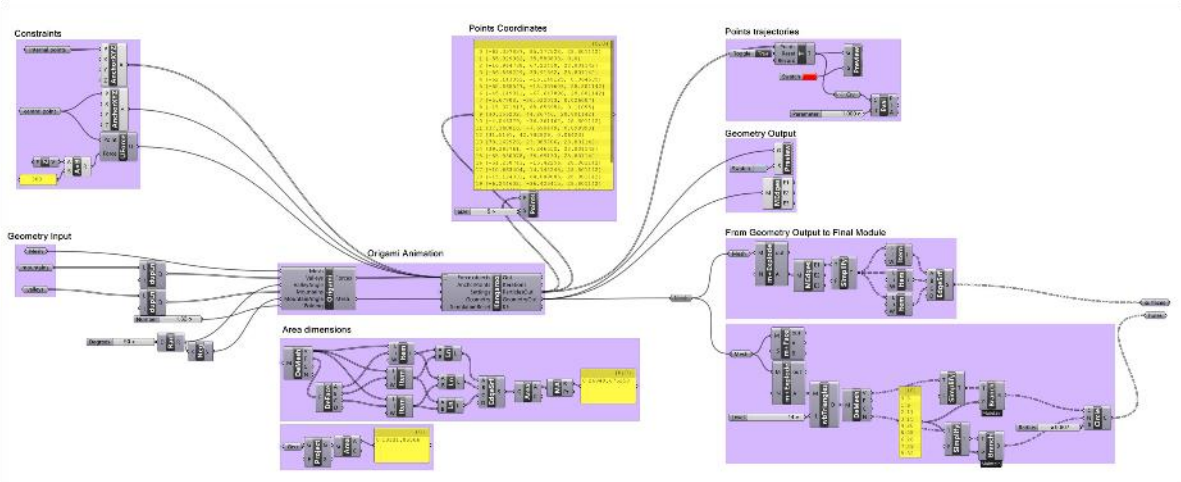
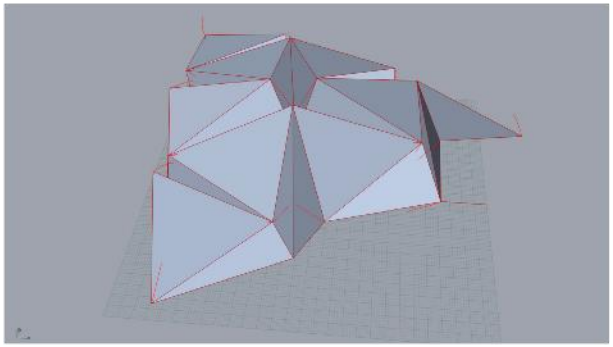
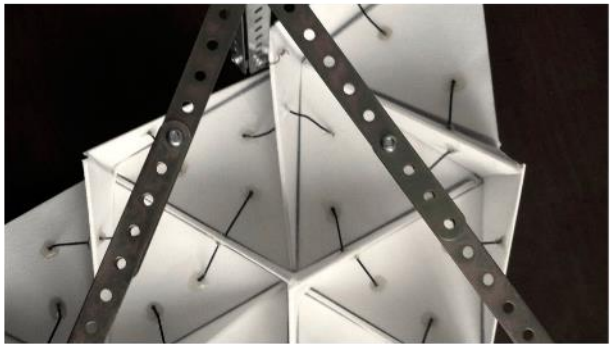
Prototyping

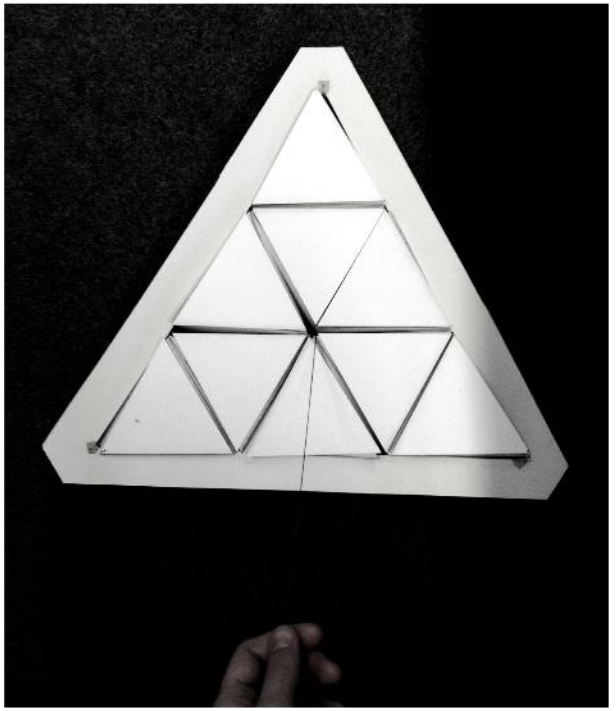
DIGITAL MODEL

Grasshopper +
Rhinoceros









PHYSICAL TEST-MODEL

Deployment analysis,
manual actuation

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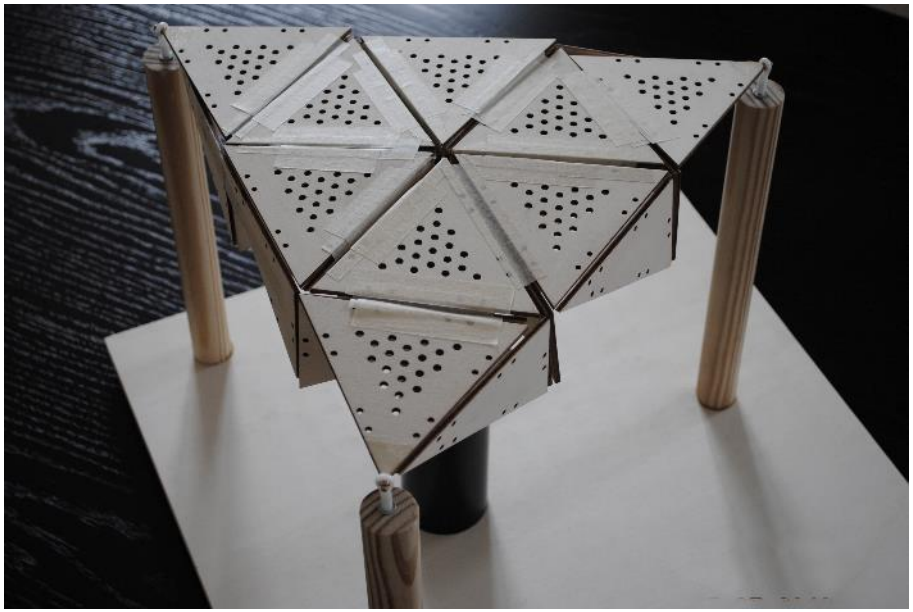
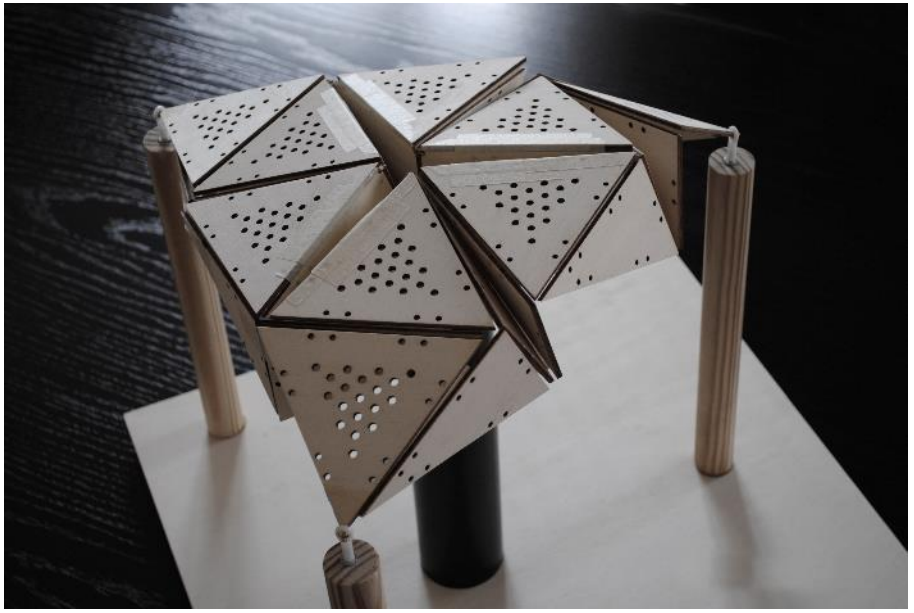
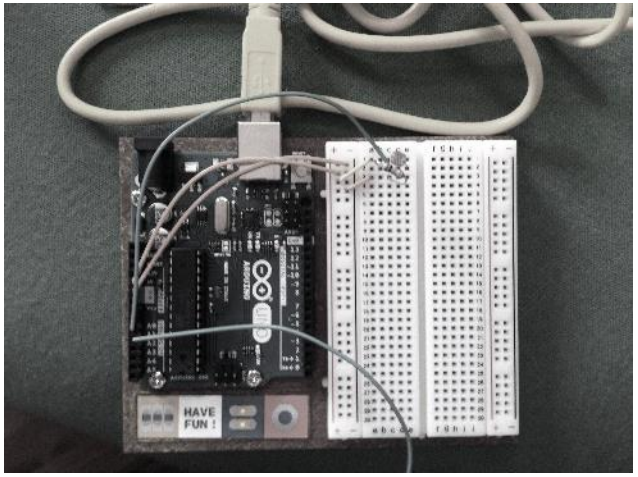
Final Prototype







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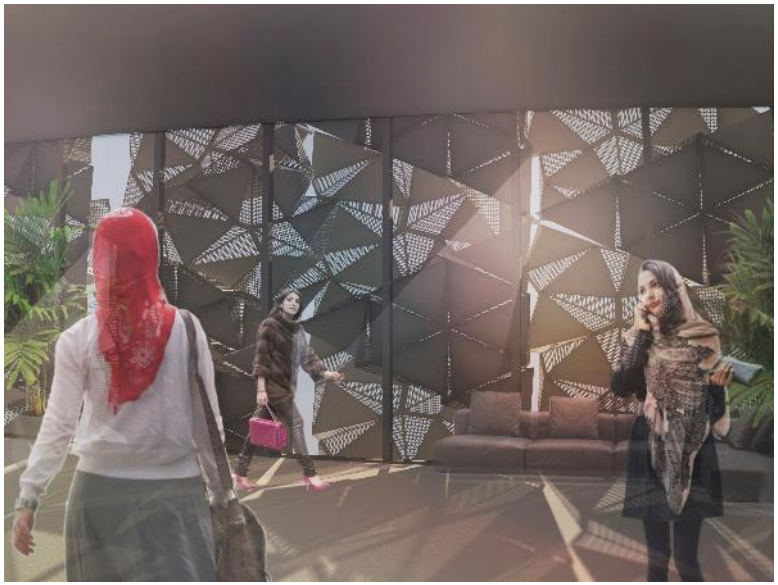
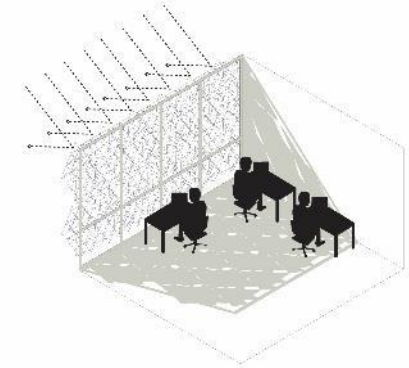
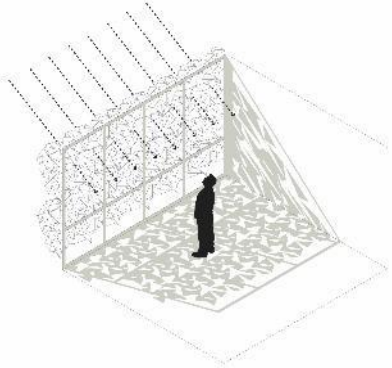
Shading Application







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Concluding remarks

- An **environment-responsive**, deployable **origami-inspired structure** has been proposed for **smart building skins**.
- The folding structure is composed by rigid panels connected to each other through hinge-like connectors.
- The overall **degree of openness** is adjusted in response to **variations of environmental parameters**, recorded by a **network of embedded sensors**.
- The geometry of the origami is selected so as the deployment can be induced at some key points that only slide along a linear axis.
- By tuning the properties of the panels, the solution can be adopted as a **shading or light refraction system**, to improve the comfort of the building interiors.
- **Digital prototyping and small-scale models** have been used to show the effectiveness of the solution.

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