Knitting with Light

Bio-Inspired Fabric Mechanics for Dynamic and Programmable Shading — First Steps

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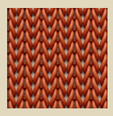
Objective: Innovate in Shading Solutions

⟹ **Sustainable Architecture (SDG 11)**: lightweight, dynamic shading for lower energy use

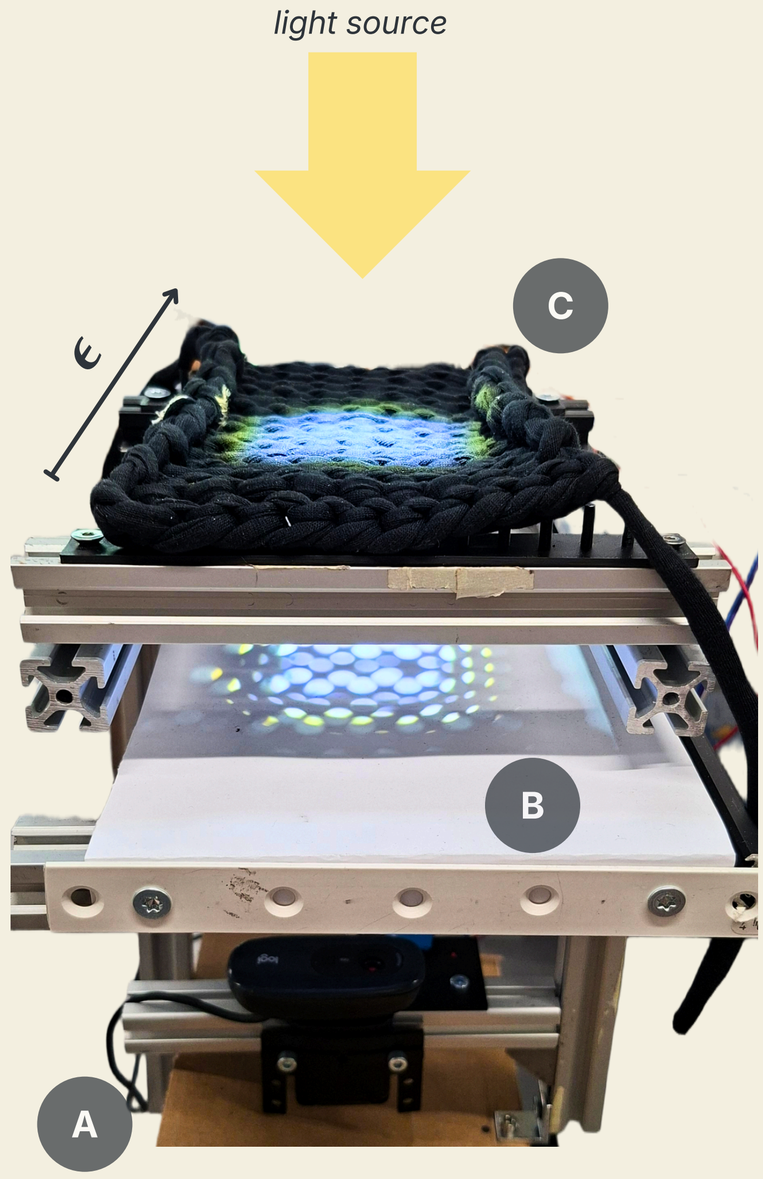
⟹ **Agriculture & Permaculture**: could help mimic natural canopy shading to restore rich ecosystems until natural cover establishes

How do we formulate **forward models** (knit deformation → shade) and **inverse models** (desired shade → knit) for these applications?

$$f(\text{  }|C) = \text{  } \qquad \tilde{f}(\text{  }|C) = \text{  }$$

C: the environmental conditions (light angle, strain in the fabric, ...)

This poster reports the first working **measurement pipeline**, focusing on how **strain** shapes the resulting **shade**.



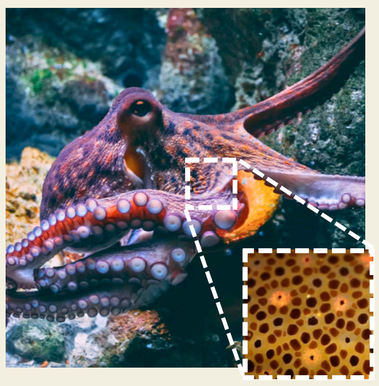
Motorized experimental setup with perpendicular incident light

(A) sensors and camera

(B) projection screen

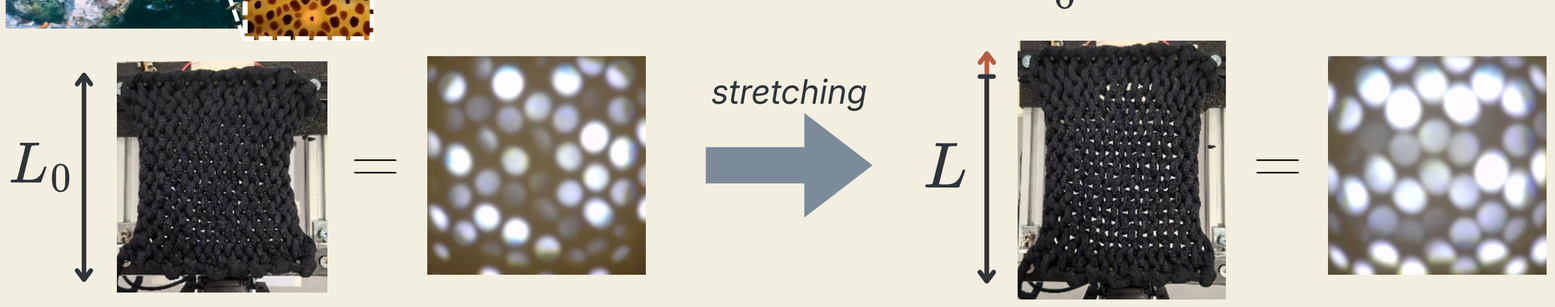
(C) fabric sample

Bio-Inspired Mechanism



Like **cephalopod** skin that uses muscle-actuated **papillae** to change light scattering, knitted structures deform under **tensile strain** (ϵ), changing loop aperture geometry, acting as a tunable lens array that shapes light into **blobs**.

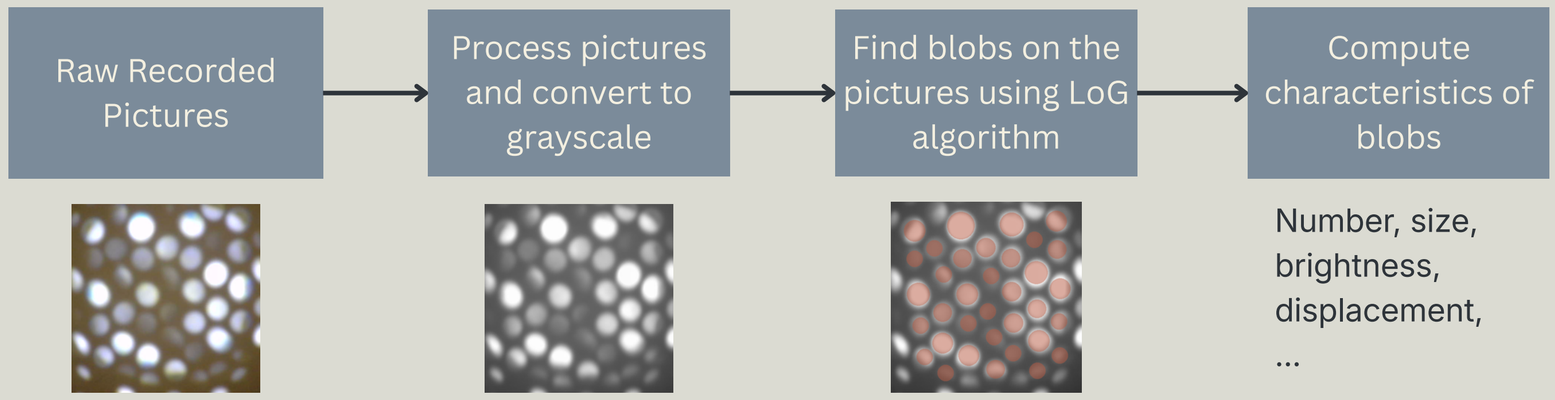
$$\epsilon = \frac{L - L_0}{L_0}$$



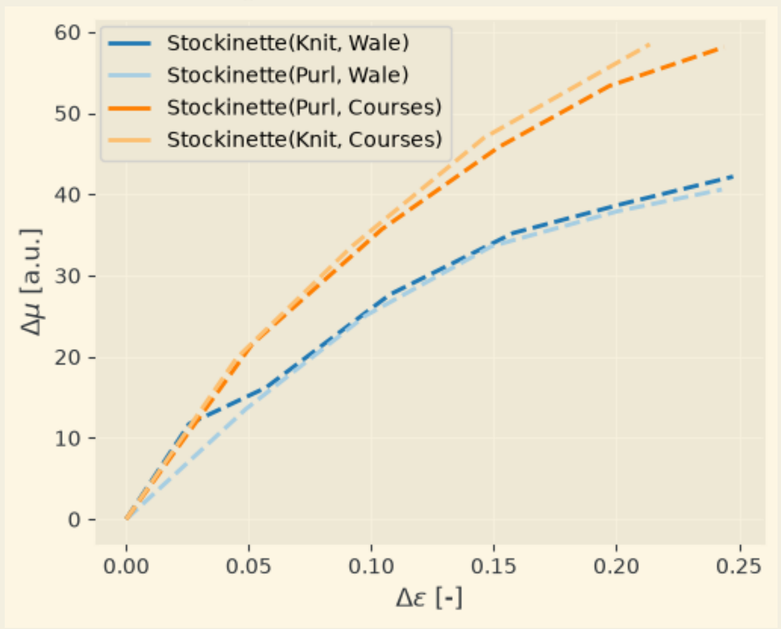
Measuring Light Blobs

As **strain** increases, blobs **grow** and **brighten**: a first quantifiable link between deformation and light transmission.

⟹ The picture can be analyzed using **computational methods** such as the LoG (Laplacian of Gaussian) blob-detection algorithm.



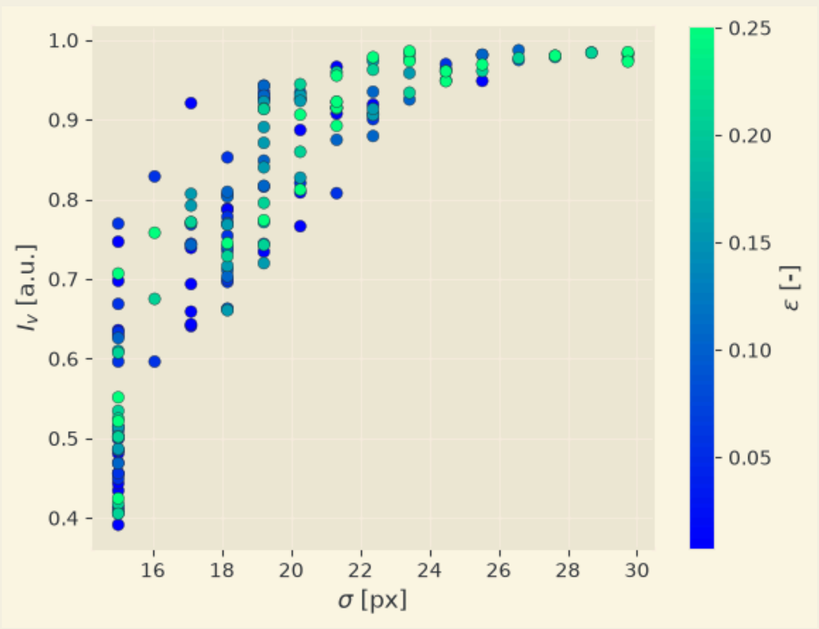
Brightness vs. Strain



Brightness of pictures (μ) taken at different strain levels (ϵ) depending on the sample's exposed side (Knit/Purl) and pulling direction (Wale/Courses)

⟹ Brightness gain is consistently higher under course-direction pulling.

Blobs Characterization



Scatter plot of the brightness (Iv) of different blobs against their size (σ) depending on ϵ

⟹ Brightness and blob size are coupled: large blobs are always bright, ruling out large, dim blobs.

Key findings

⟹ Under **perpendicular light, pulling direction** (≠ exposed side) controls how bright the transmitted pattern is

⟹ Not all **light motifs** are achievable (ex. large, dim blobs)

Status and next steps

Setup and pipeline validated across multiple strain levels and pulling directions on stockinette samples.

⟹ Extend to other stitches and fit an explicit forward model linking strain to blob statistics

⟹ Test whether desired shading patterns can be achieved by selecting knit parameters