Auxetic Materials

We present a computational method for interactive 3D design and rationalization of surfaces via auxetic materials, i.e., flat flexible material that can stretch uniformly up to a certain extent. A key motivation for studying such material is that one can approximate doubly-curved surfaces (such as the sphere) using only flat pieces, making it attractive for fabrication. We physically realize surfaces by introducing cuts into approximately inextensible material such as sheet metal, plastic, or leather. The cutting pattern is modeled as a regular triangular linkage that yields hexagonal openings of spatially-varying radius when stretched.

Conformal Geometry

In the same way that isometry is fundamental to modeling developable surfaces, we leverage conformal geometry to understand auxetic design. In particular, we compute a global conformal map with bounded scale factor to initialize an otherwise intractable nonlinear optimization. We demonstrate that this global approach can handle non-trivial topology and non-local dependencies inherent in auxetic material.

One attractive feature of conformal geometry is that the curvature of a surface is easily expressed using the logarithmic scale factor:

$$K = \frac{1}{\log(\lambda)}$$

Reconfigurable Surfaces

An interesting property of auxetic materials is that with the same piece of material one can approximate various shapes. Furthermore, they can be used as transformable surfaces, i.e. animated structures that can change the geometry over time. Reconfigurable surfaces have a variety of application fields, including the shading and lighting systems in architecture.