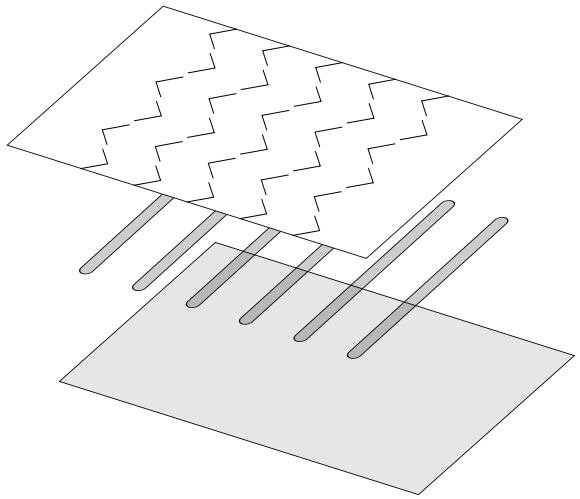
MECHANISM

In nature, animals employ node-based surfaces such as hairs, scales, and spines. These surface features are frequently actuated by changing skin surface length through methods such as muscle flexion, air bladders, or other swelling mechanisms. In natural contexts, the visual changes of these surfaces are synchronous with changes to the animals state or behavior such as aggression, arousal, or fear. For example, porcupines use quills that change angle when threatened, changing both the visual communication to predators and the mechanical performance of the quills, allowing them to more easily contact a predator.

Our mechanical method follows this biological inspiration. The system is comprised of three major elements:

- a thin, buckling top sheet, such as paper, plastic, or fabric, which becomes the contact surface
- the bonding regions used to secure the top sheet
- an elastic substrate sheet that provides the compressive force that, in conjunction with the selective bonding and perforations, actuates the uniform surface change

Each of these three elements can be tuned and created with a range of materials and processes, yielding different results.



At a fundamental level, the 'pop-up' or shape-changing behavior occurs due to the differential compressive forces on the two layers. The pre-strained elastic substrate forces the thin, deformable top layer to buckle. Selective attachment of the top and bottom layers in the pre-programmed rows limits the buckling to localized rows of material.

These surfaces are assembled with the substrate layer stretched, such that their default state after fabrication is as an actuated, 'pop-up' surface.

After that, the surface can be tuned by re-straining the elastic substrate. If the substrate is stretched fully back to the as-fabricated length, the surface will return to flat; a linear actuation system could target either discrete levels of actuation or a continuous and gradual surface change. This can be achieved with a motor or other electronic actuator.

Try it! To try out one of these surface features yourself, print out this document, cut along the dotted lines, place it on a flat surface, and push the shaded areas together. You can try shaping or modifying the cut line and shape to see the different possible visual and physical effects!