## Supplementary information Of

## A smart finger patch with coupled magnetoelastic and resistive bending sensors.

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## Supplementary Text

## Supplementary Text1: Optimization of Magnetized Micropillars

The magnetized micropillars adopt a cylindrical design with a domed top. This shape offers superior responsiveness to the complex combination of normal and shear forces experienced by the index finger when interacting with objects. The gradual curvature of the domed top allows for efficient force distribution and detection across various angles of applied force, enhancing sensitivity to oblique forces common in grasping. Moreover, the domed shape adapts better to various object curvatures and minimizes edge effects, ensuring consistent sensing across the entire pillar surface. This design allows for accurate detection of a wide range of force magnitudes, from gentle touches to firm grasps.

The optimization process involved comparing devices with pillar heights of 0, 1, 2, and 3 mm, all with a base thickness of 1 mm. As shown in **Fig. S1**, when subjected to a 0.5 mm indentation of normal pressure loading, the device without pillars (0 mm)

produced an almost imperceptible output. The 1 mm pillar device yielded a relatively small output (-1.2  $\mu$ V) compared to the 2 mm device (-4.8  $\mu$ V). While the 3 mm device generated a higher output, its increased aspect ratio led to inconsistent bending behavior during each compression, resulting in significant output fluctuations. **Fig. S2** demonstrates the bending behavior of 2 and 3 mm devices under 0.5 mm compression. The 2 mm device exhibits more consistent bending behavior, while the 3 mm device shows variations (as indicated by the yellow arrows). Based on these results, the 2 mm height was selected as the optimal parameter for the device. This height offers a balance between sensitivity and stability, providing a detectable signal while maintaining consistent performance.



Supplementary Figures

**Fig. S1.** The voltage intensity of the magnetized micropillars with heights of 0, 1, 2, and 3 mm are compressed by 0.5 mm



**Fig. S2.** Optical images of magnetized micropillars with heights of 2 and 3 mm under 0.5 mm compression from an indenter moving in the normal direction.



Fig. S3. The response time and recovery time of the MEG sensor.