Large Scale Sensing System for Structural Health Monitoring

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Motivation
- Preserving the structural health of buildings and bridges.
- Detecting small cracks on large structures.

Challenges:
- Continuously monitoring minute changes of the geometric properties of a structure over meter-sized areas using large-area electronics.

Strain Sensors on LAE Sheet
- Strain sensors on the LAE sheet were designed by using a bridge configuration based on resistors made of constantan.
- Constantan is a metal alloy that remains with constant dimensions over a wide range of temperatures.
- The Gage Factor(GF) of a strain sensor relates the change in resistance to the strain.

Theory
- Development of analytical model for the strain at any point on the top surface of a loaded cantilever beam as a function of the distance “x” from the support point and its curvature “1/p” at that point (which depends on the deflection “v” of the beam in the vertical direction).

\[
\varepsilon = \frac{\Delta L}{L} \rightarrow \varepsilon = -\frac{t}{2p} \quad \text{and} \quad \frac{1}{p} = \frac{d^2v}{dx^2} = v''(x) = -\frac{mg}{EI} \ast (L - x)
\]

Therefore:
\[
\varepsilon = \frac{t}{2} \ast \frac{mg}{EI} \ast (L - x)
\]

Fig. 1: A MATLAB strain readout from a 4x4 array of strain sensors.

Results
- Achieved a sensitivity of 20 micro strains on strain gauges on LAE plastic sheets.
- Demonstrated a 2-D array strain readout.
- In the future, this large-area strain-sensing sheet might be tested on buildings and bridges to prevent major catastrophes.

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References: