Large Scale Sensing System for Structural Health Monitoring

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Preserving the structural health of buildings and bridges requires early damage detection and continuously monitoring minute changes of the geometric properties of the structure. Strain is a measure of the relative change in dimensions of an object when is subject to a force (stress) compared to its regular (unstrained) dimensions, therefore making strain a good measurement of the health of a structure.

This work focuses in the development of a system that senses the changes in strain along the surface of a structure by the implementation of thin film sensing sheets with arrays of strain sensors implemented using large-area electronics (LAE) technology, enabling high spatial resolution sensing over large areas of any structure.

The LAE flexible sheet circuitry and the strain sensors were designed by Levent Aygun. The sheet is made of a flexible polyimide substrate that holds both the sensors (16x16) and the control signal components. The strain sensors were designed by using a bridge configuration based on resistors made of constantan, which is a key material for this application because its dimensions remain constant over a wide range of temperatures, allowing us to detect small changes in voltage due only to strain. For the calibration of the sensors, I developed an analytical model for the strain on the top surface of a loaded cantilever beam as a function of distance from the support point. Using the gauge factor of commercial sensors, the strain measured by our system agreed with the predicted strain with 5 % error. Then I determined the gauge factor of the constantan sensors by simultaneously reading off the changes in the voltage signals -due to strain- coming from our sensors and the commercial sensors at the same time.

In this project we achieved multi-channel strain readout with sensitivity of 20 micro strains [1]. In the future, this large-area strain-sensing sheet might be tested on buildings and bridges to prevent major catastrophes.

Fig. 1: LAE strain sensing system, containing signal control components, read by a Data Acquisition Device.
Fig. 2: A MATLAB strain readout from a 4x4 array of strain sensors.