



If Bridges Could Talk...

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188 million daily crossings on structurally deficient bridges.

\$123 billion needed for bridge rehabilitation

21 years at the current funding level

One of 10 bridges with weight/speed restrictions



Smart Bridges



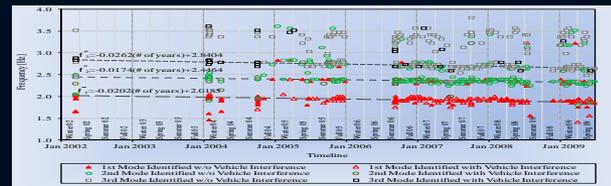
I-35W Bridge



Tsing Ma Bridge: \$22,875 per sensor



Cost



Benefit ?

Evolution toward Internet of Smart Bridges



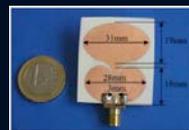
1990

2000

2010

2020

Traditional sensors → Emerging sensors → Ubiquitous sensors → Smart sensors



Fiber optic and MEMS sensors

Subsurface imaging sensor



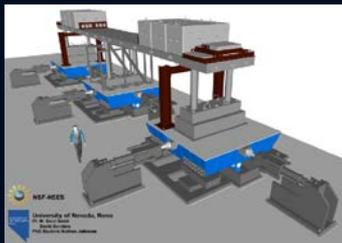
Vision sensors

Smartphone sensors

Multifunctional Computing
Communication
Control
Smart materials
Energy harvesting

Data analytics for damage detection & condition assessment

Machine learning



Diagnostics & prognostics

Intelligent maintenance
Post-disaster response
Resiliency planning

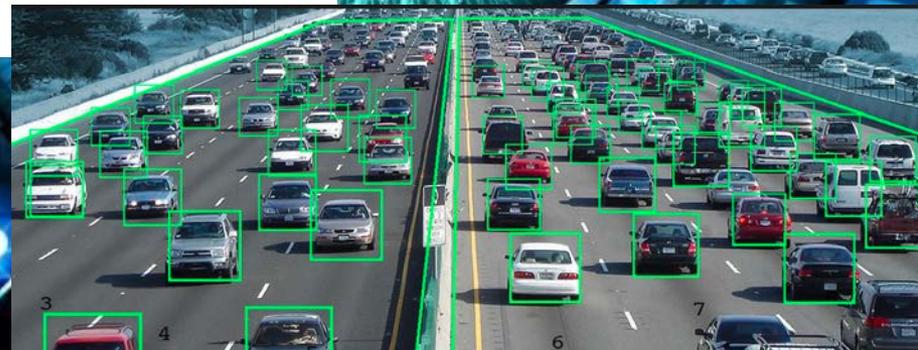
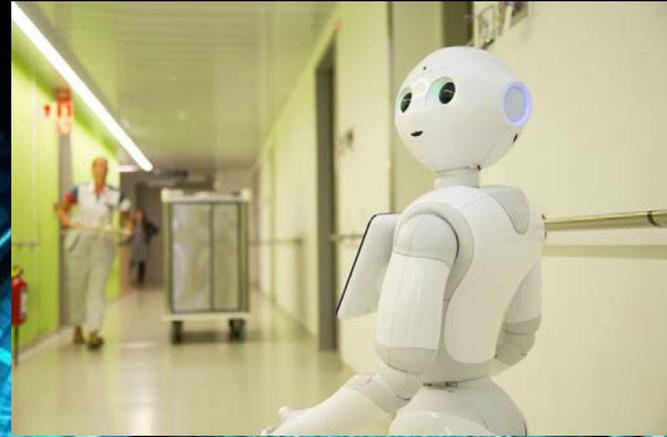
Lab tests

Field instrumentation
Long-term database

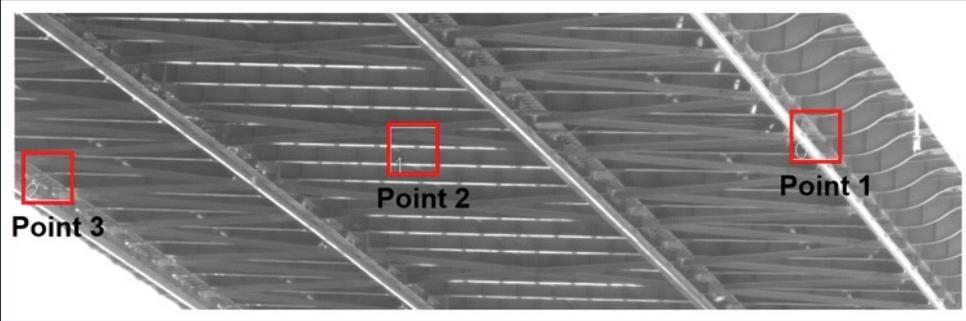
Networked systems

Decision making

Computer Vision

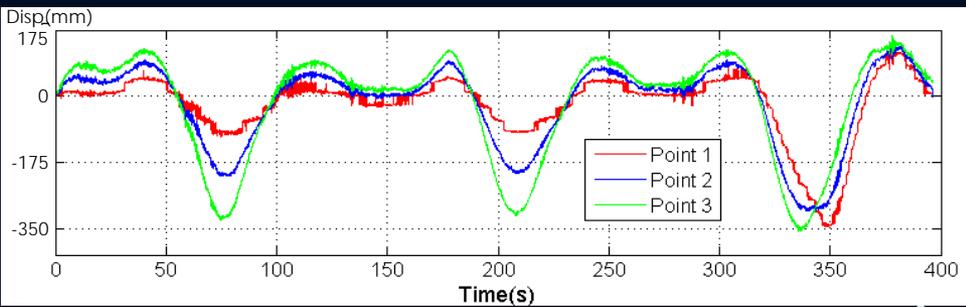
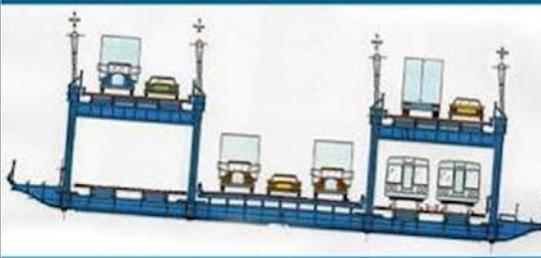


Computer Vision for Structural Health Monitoring

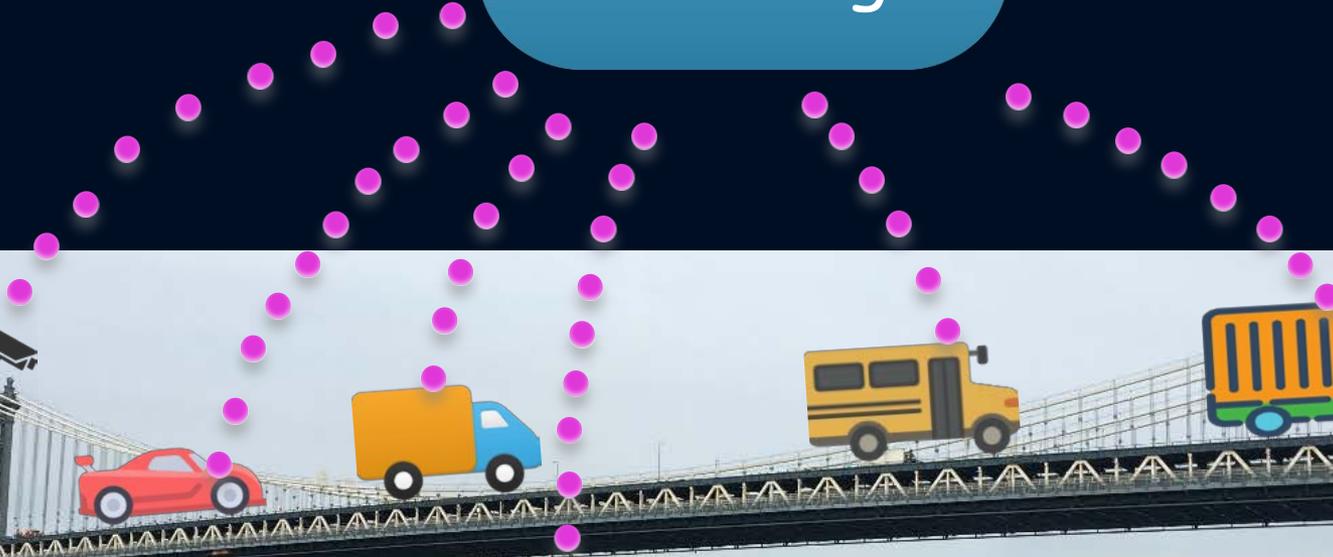


Differential Displacement: MANHATTAN BRIDGE

Before: 2,438mm
After: 210mm



Internet of Things





A camera takes video footage of roads along a postal route, detecting potential pavement problems



When the vehicle returns to the post office's wifi range, the data uploads to the cloud



The data is downloaded to a computer, where the algorithm analyzes it and maps pavement conditions



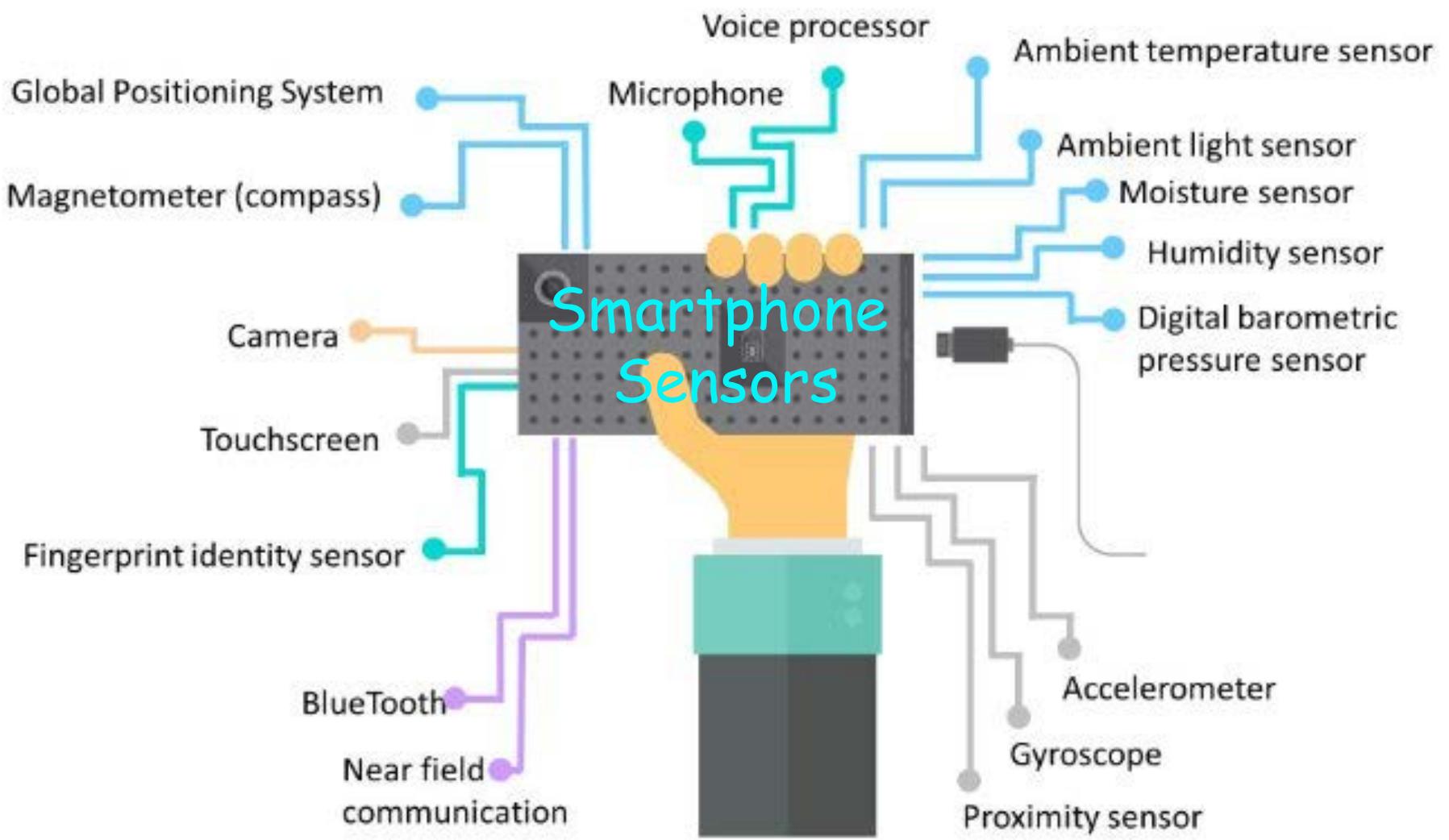
1. Postal vehicle drives over bridge

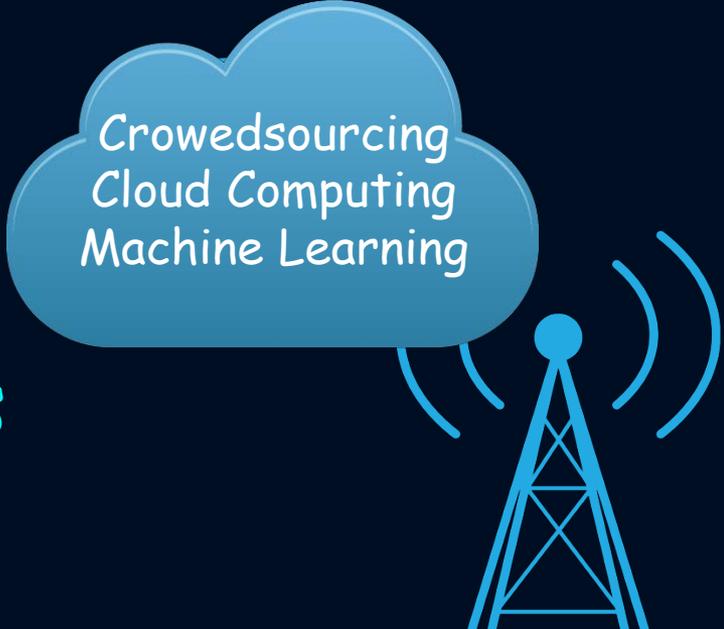
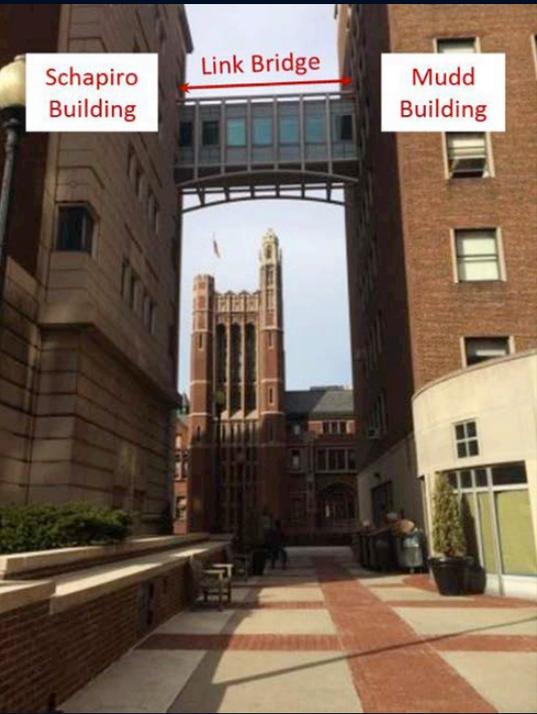
2. Accelerometer in vehicle records vibration patterns

3. Data is transmitted to the cloud

4. Vibration patterns are measured against baseline patterns to detect anomalies



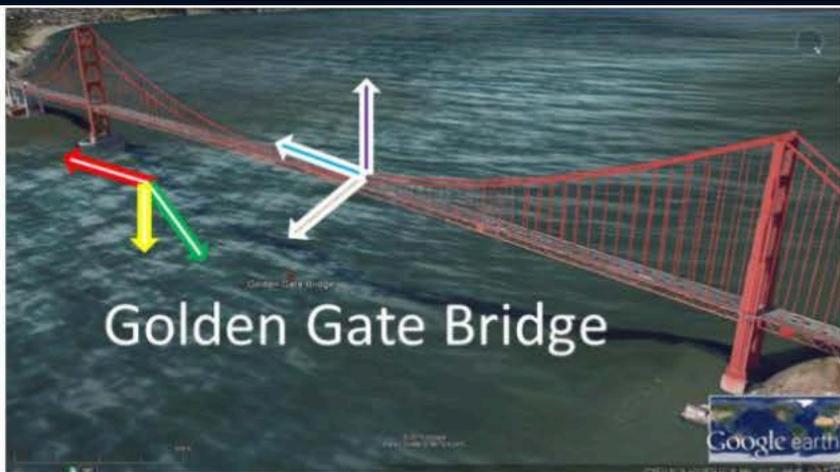




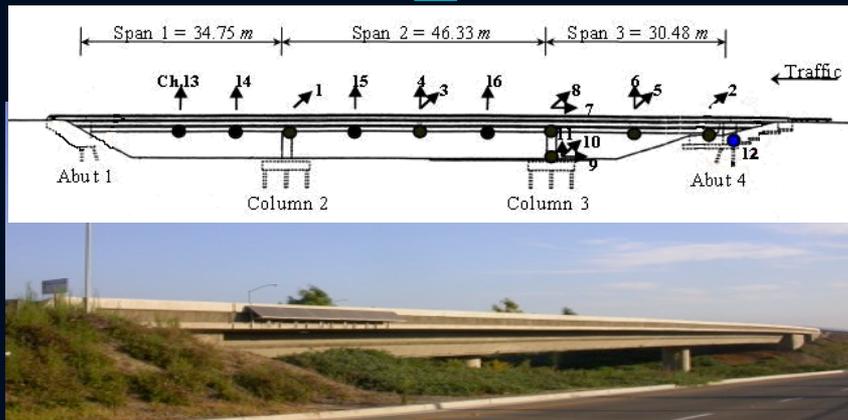
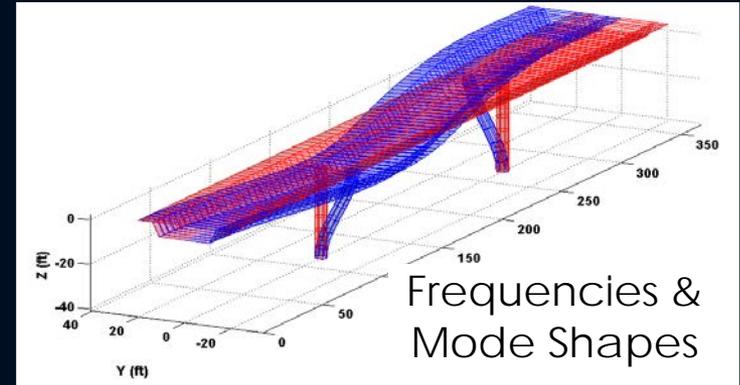
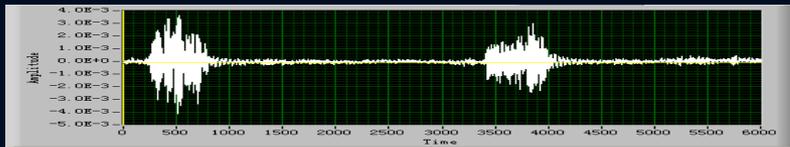
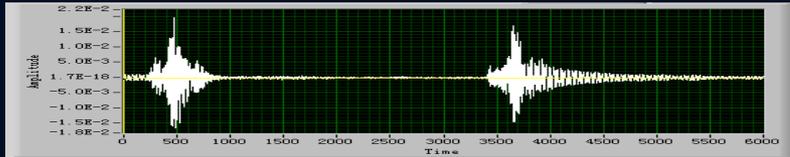
Citizen Sensors



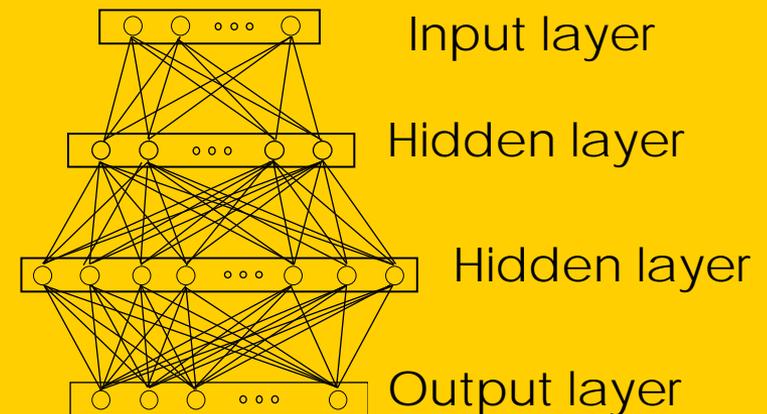
An iOS App



Application of Artificial Neural Networks in SHM



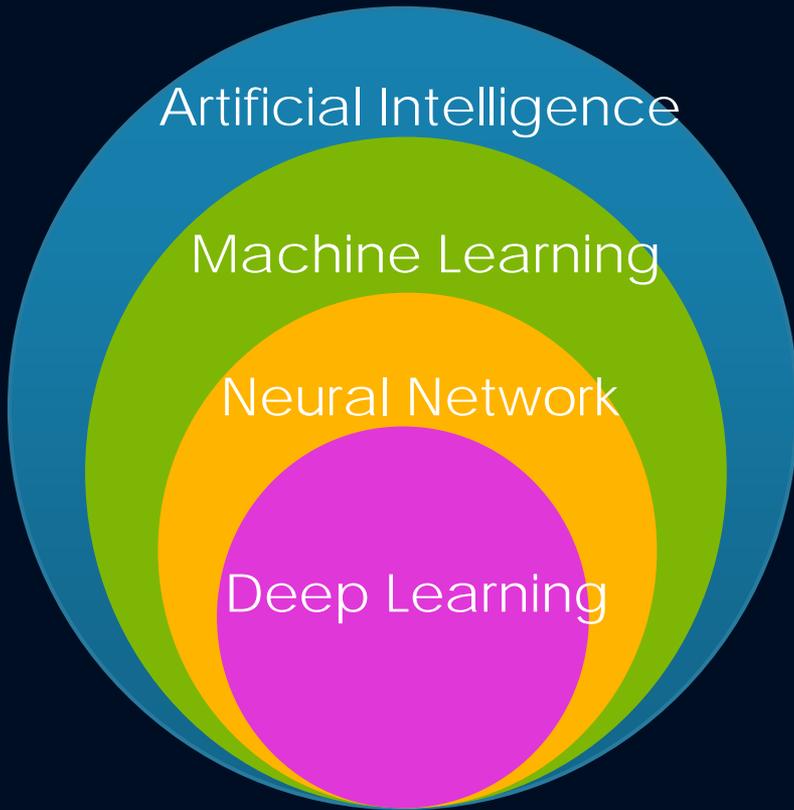
Artificial Neural Network (ANN)



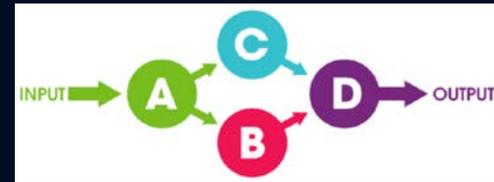
Assessment of structural Health

Change of Stiffness from Baseline



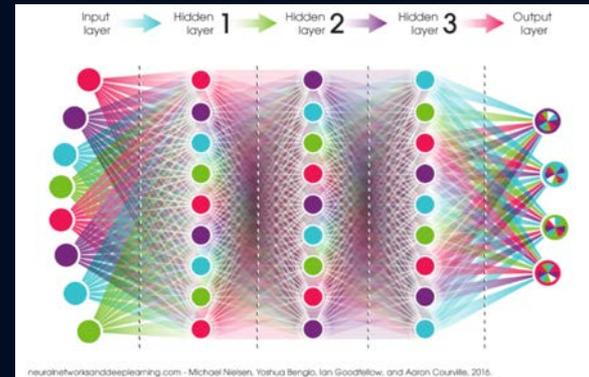


Neural Network:



Shallow layers
Supervised learning

Deep Neural Network:



Deep layers
Supervised or unsupervised learning

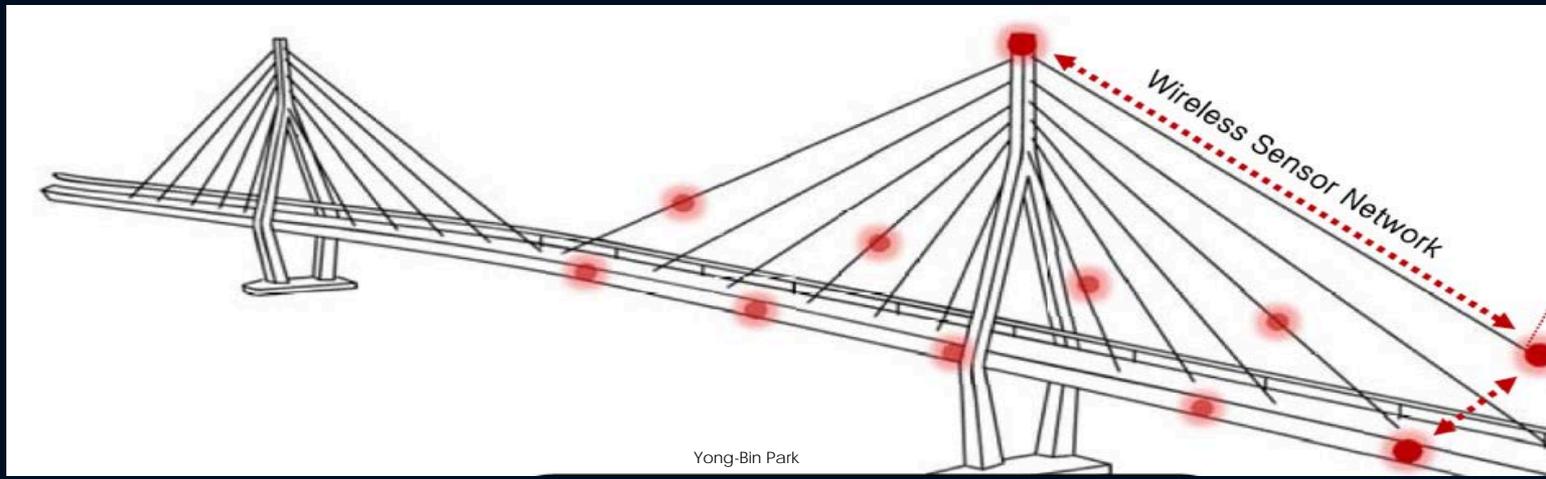
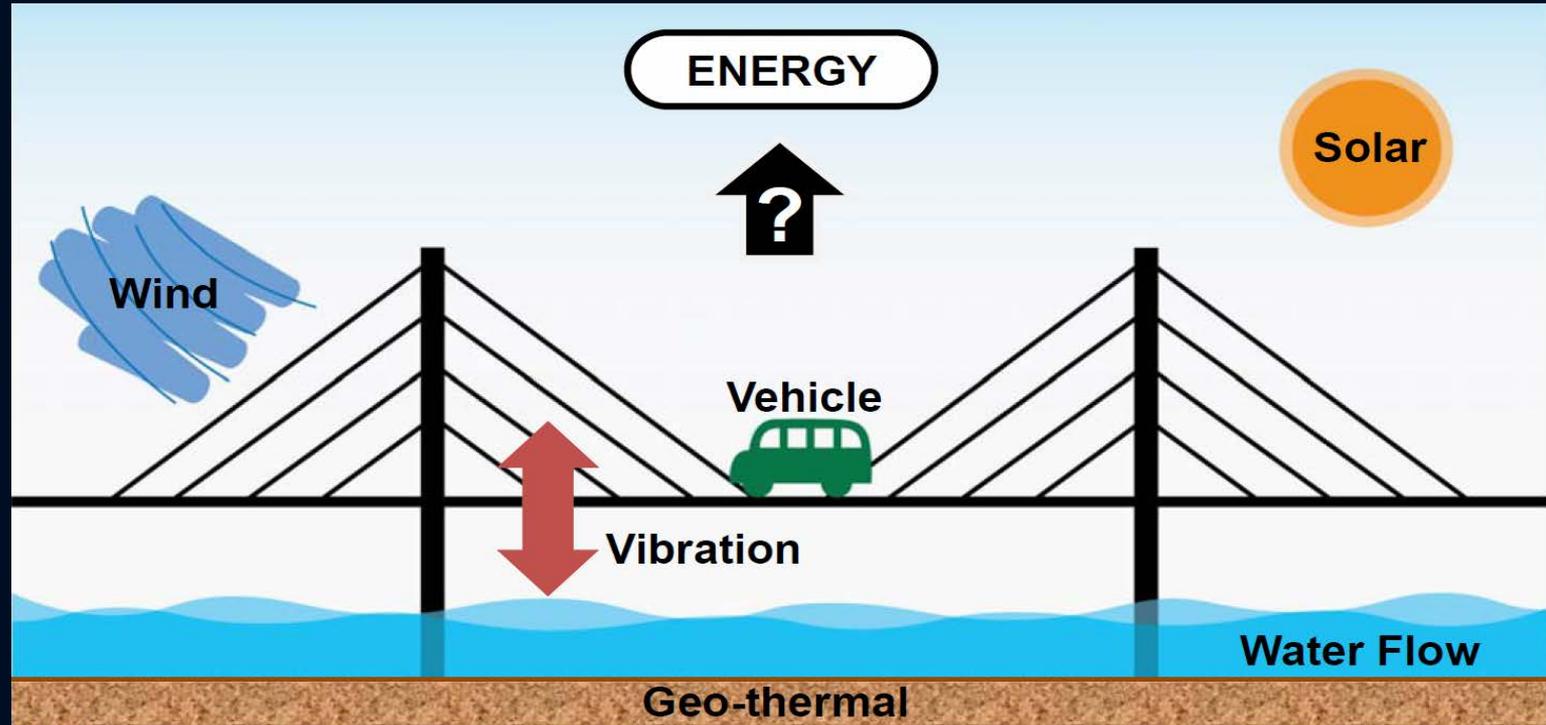
Applications:

Image recognition

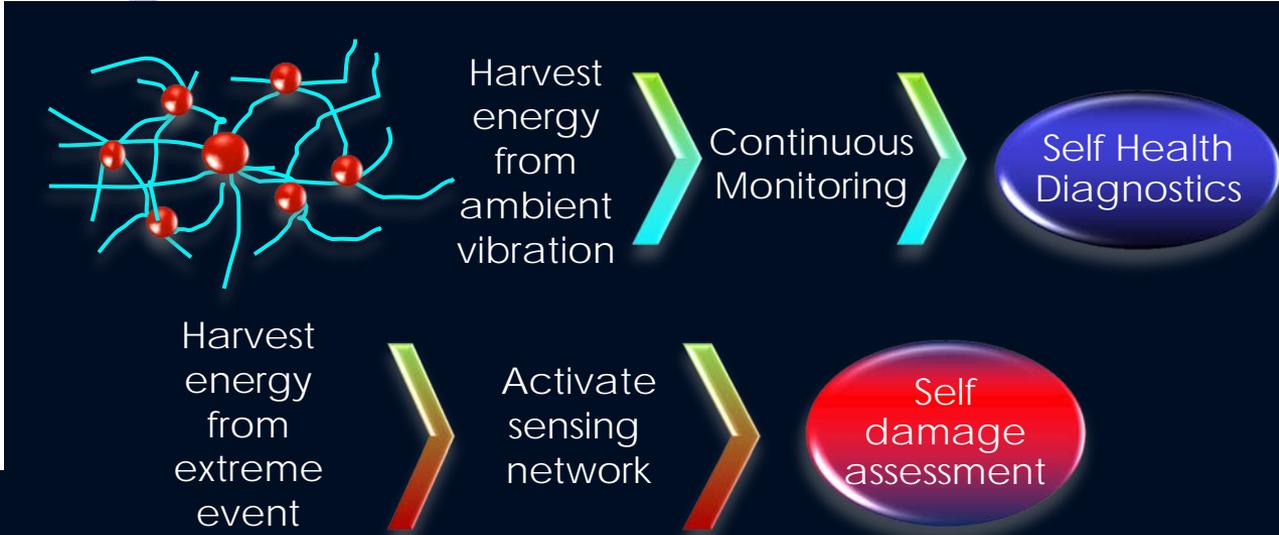
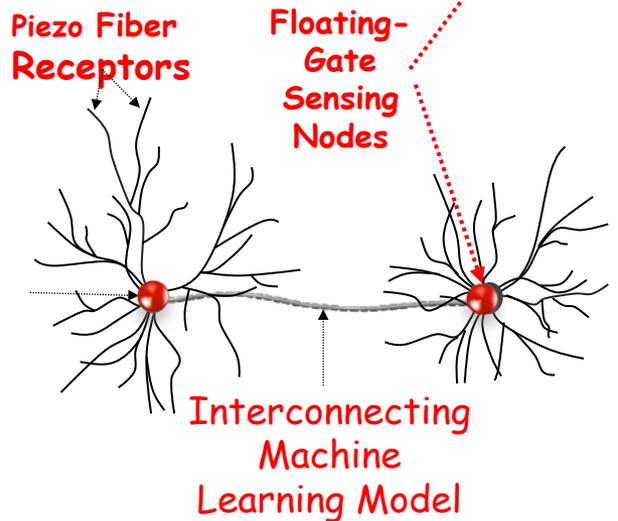
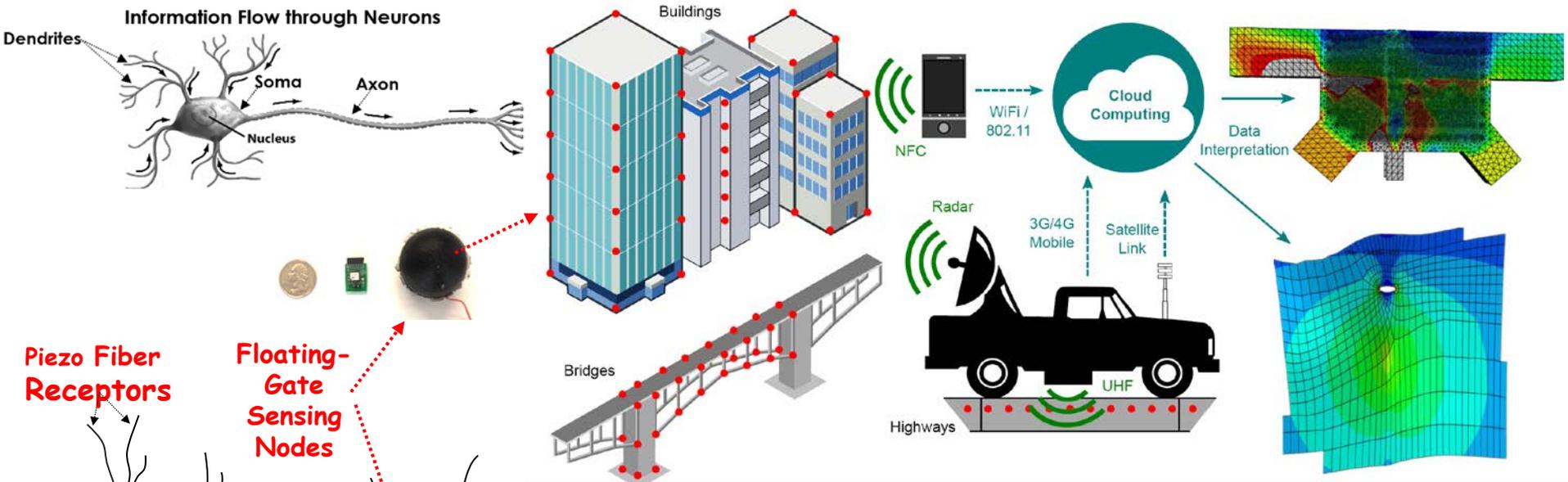


Speech recognition

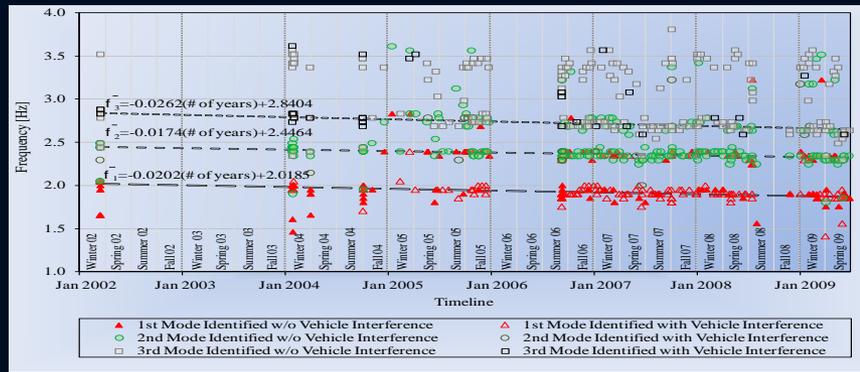
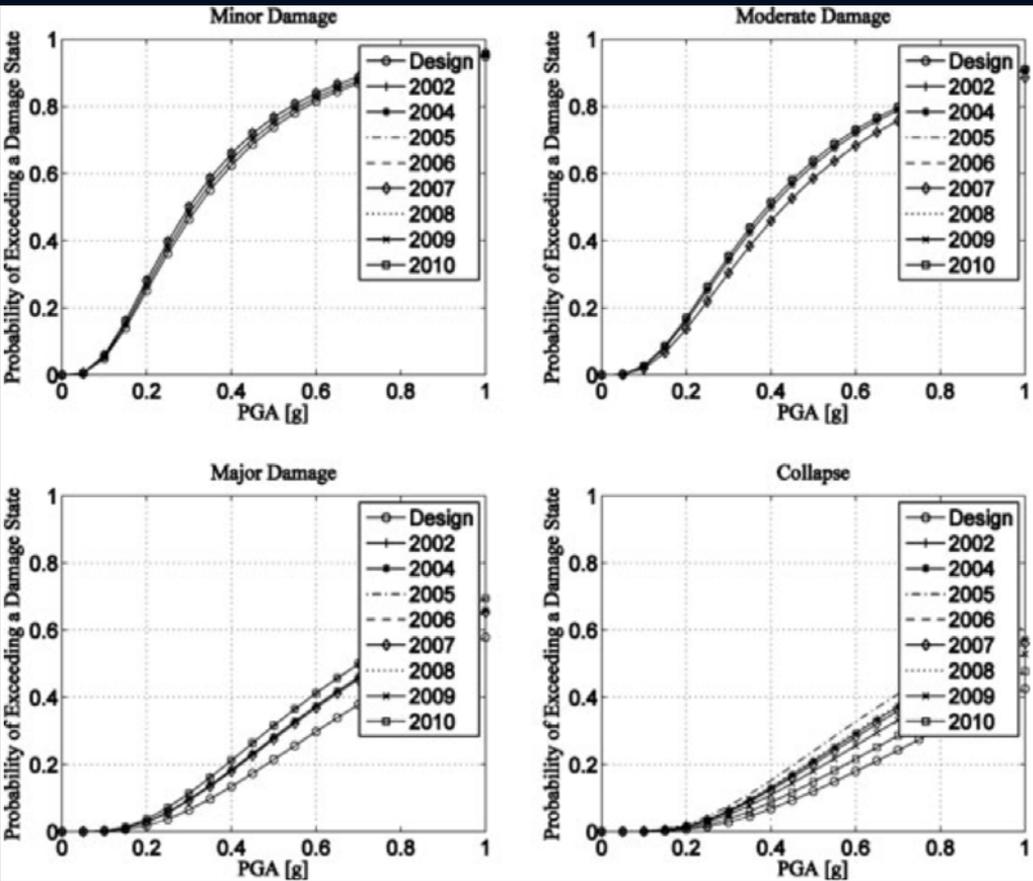
Self-Powered Smart Structure



Bio-Inspired Smart Materials & Structures

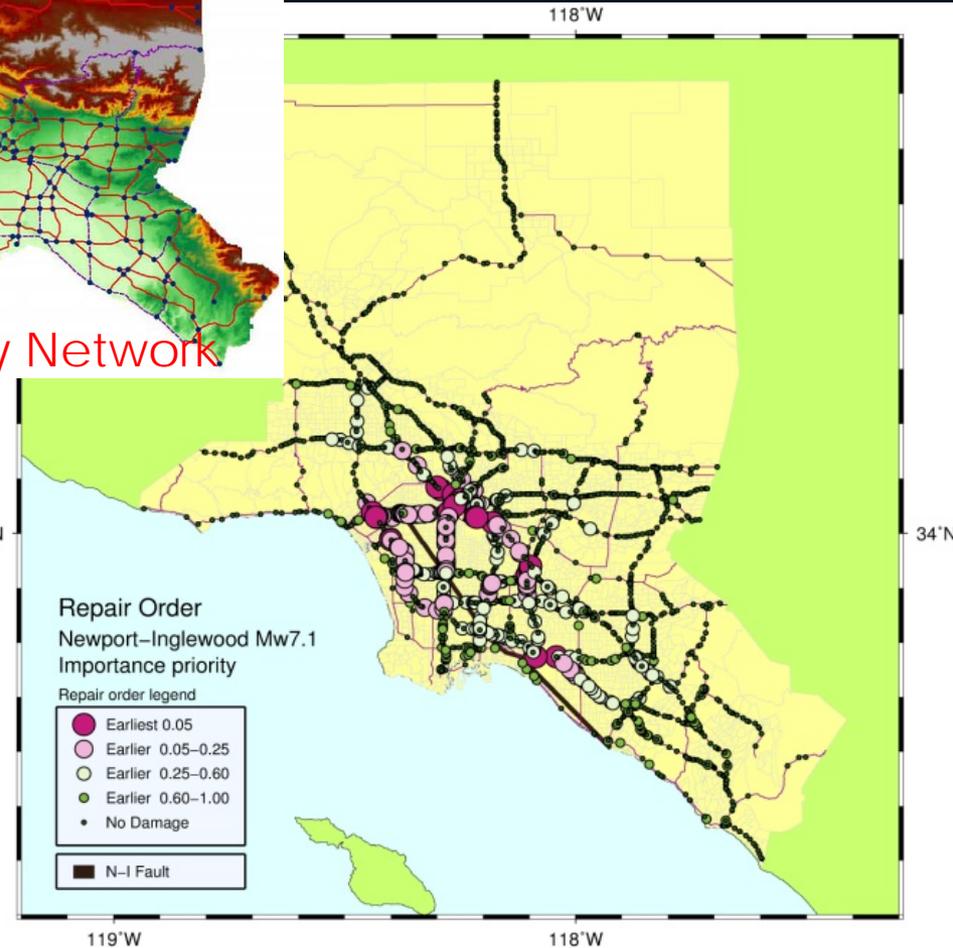
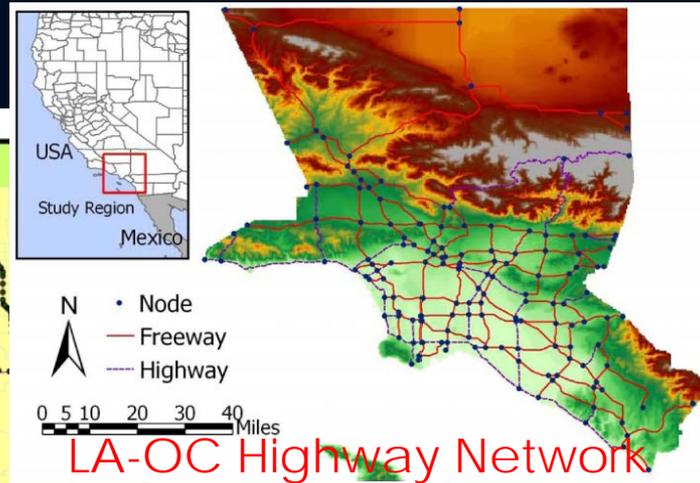


From Diagnostics to Prognostics to Resiliency



Update Seismic Fragility Using 8-Years of Bridge Monitoring Data

From Diagnostics to Prognostics to Resiliency



Repair Prioritization Based on Cost

Based on Importance

