



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

BUN/EN/Flickr



Smart Bridges



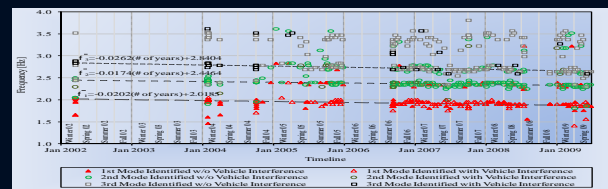
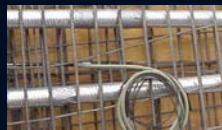
I-35W Bridge



Tsing Ma Bridge: \$22,875 per sensor



Cost



Benefit ?

Evolution toward Internet of Smart Bridges

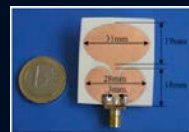
1990

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

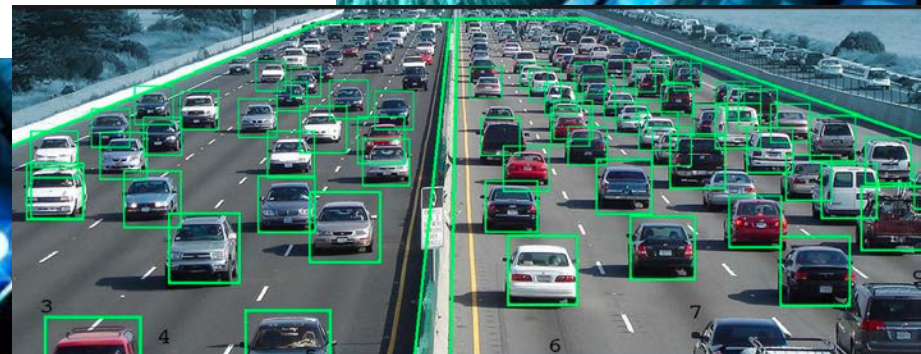
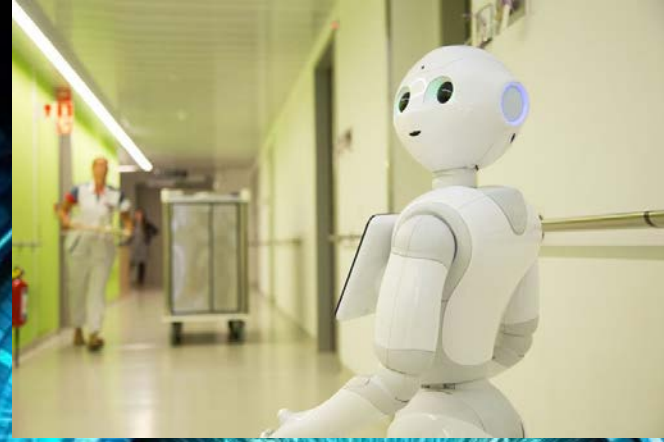
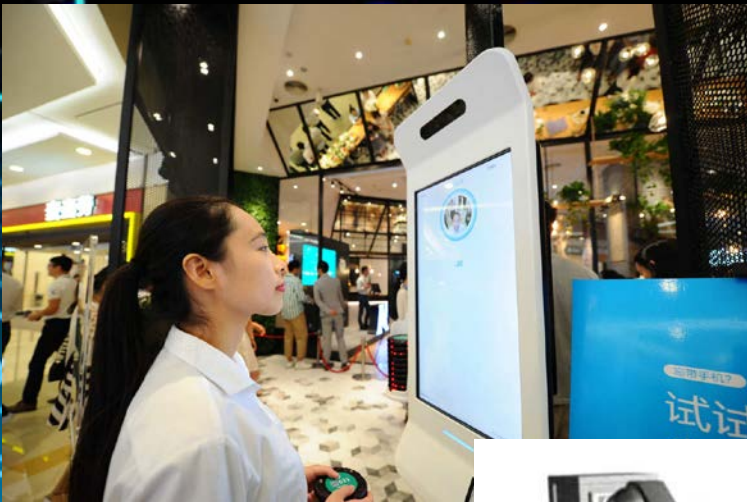
Lab tests ➔

Field instrumentation
Long-term database ➔

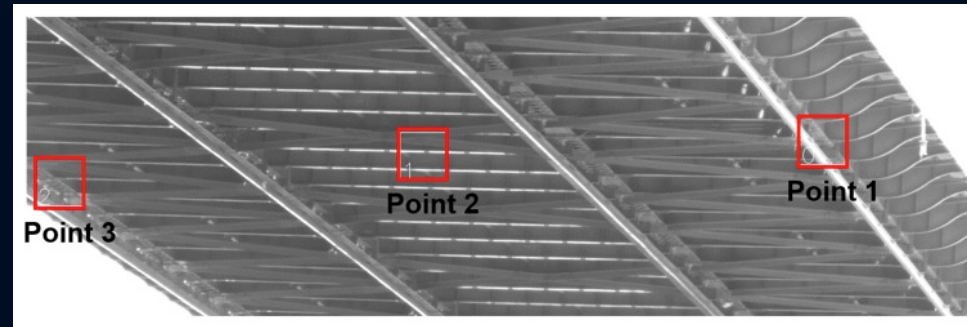
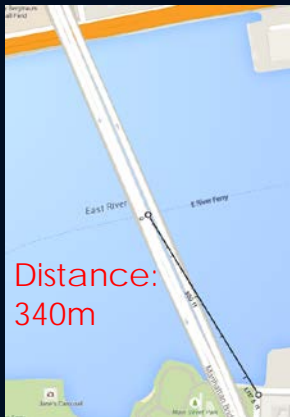
Networked systems ➔

Decision making

Computer Vision

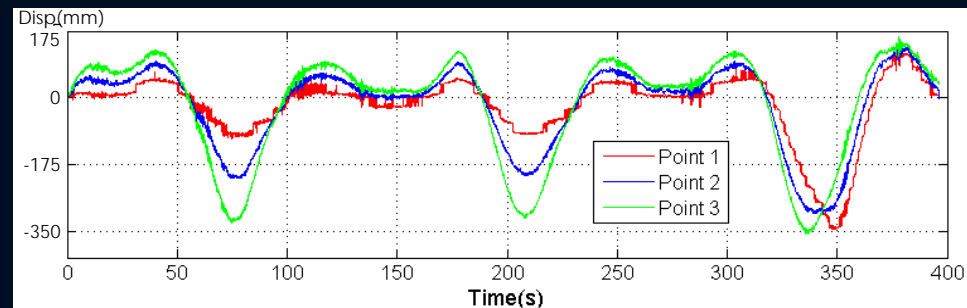
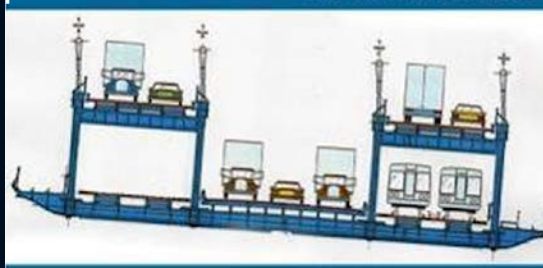


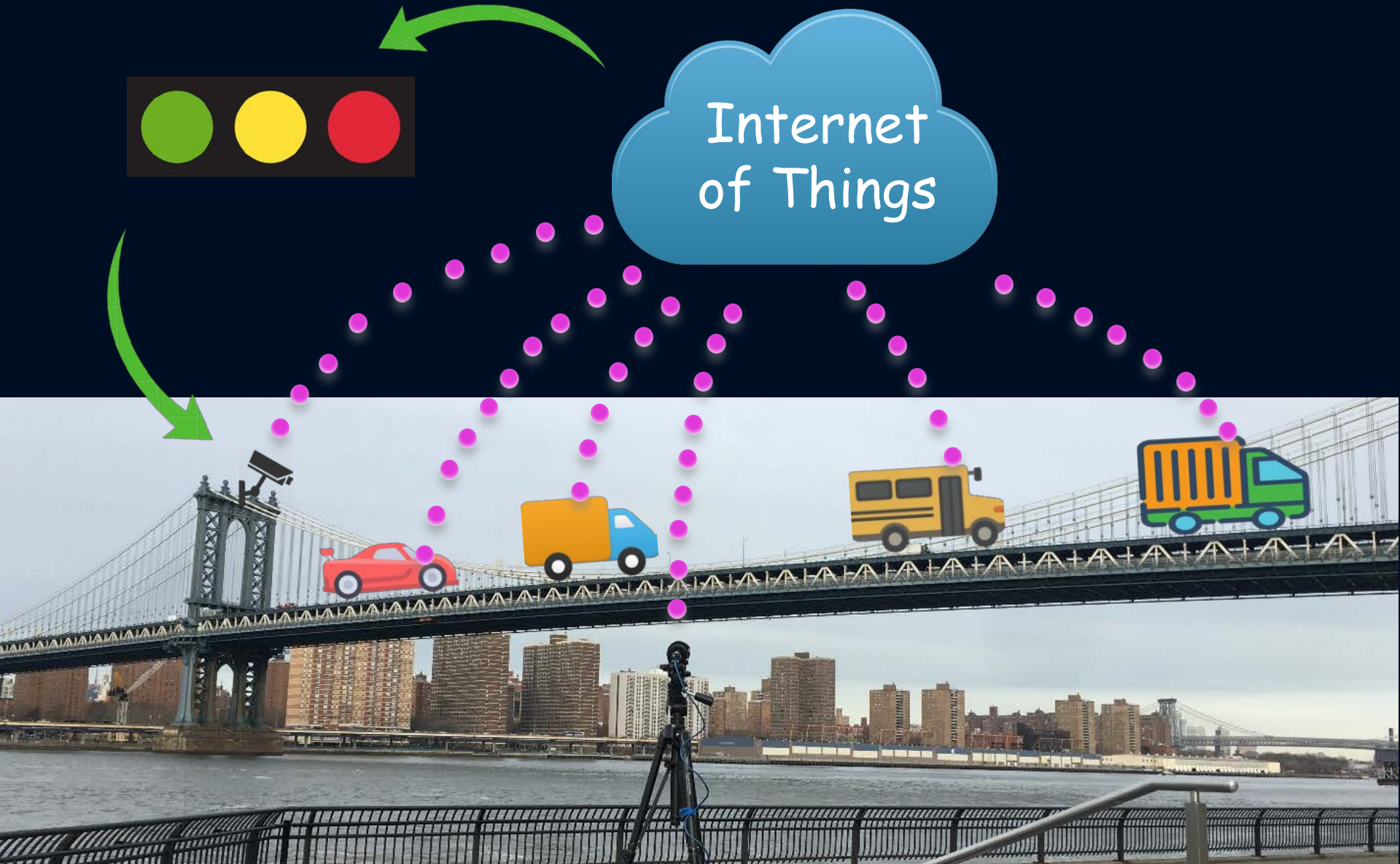
Computer Vision for Structural Health Monitoring



Differential Displacement:

Before: 2,438mm
After: 210mm







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



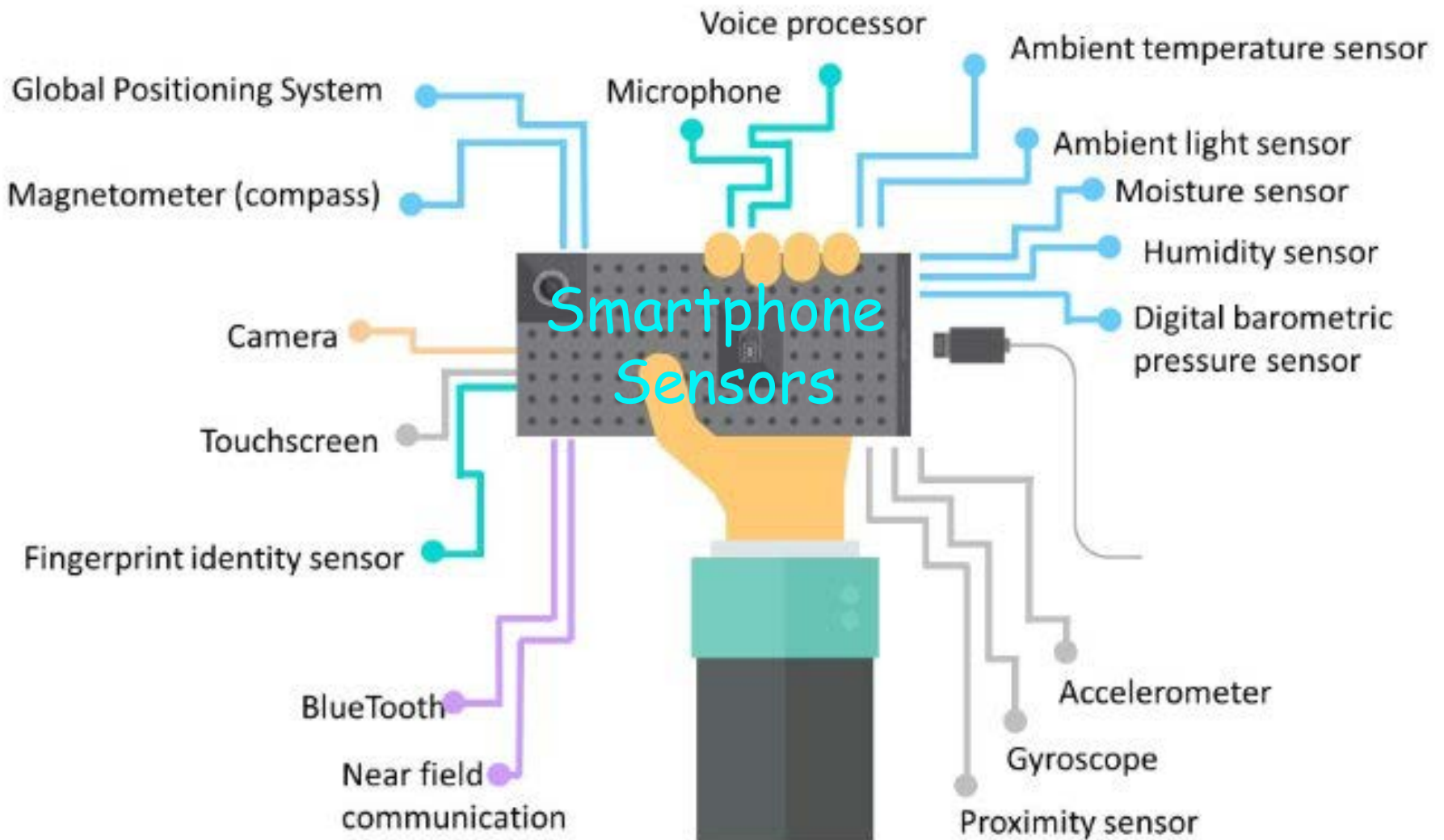
1. Postal vehicle drives over bridge

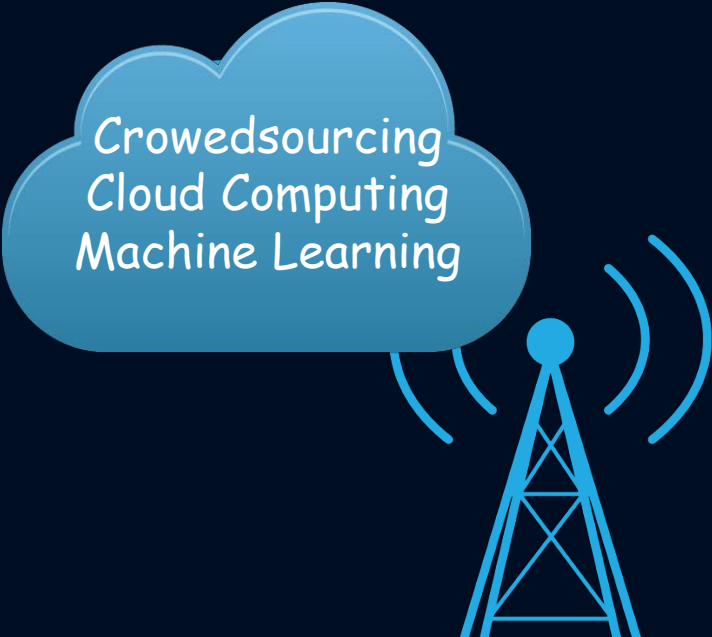
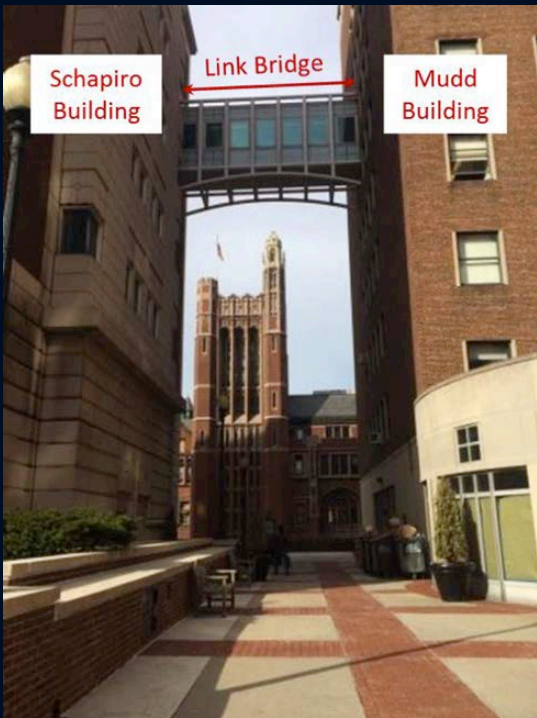
2. Accelerometer in vehicle records vibration patterns

3. Data is transmitted to the cloud

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



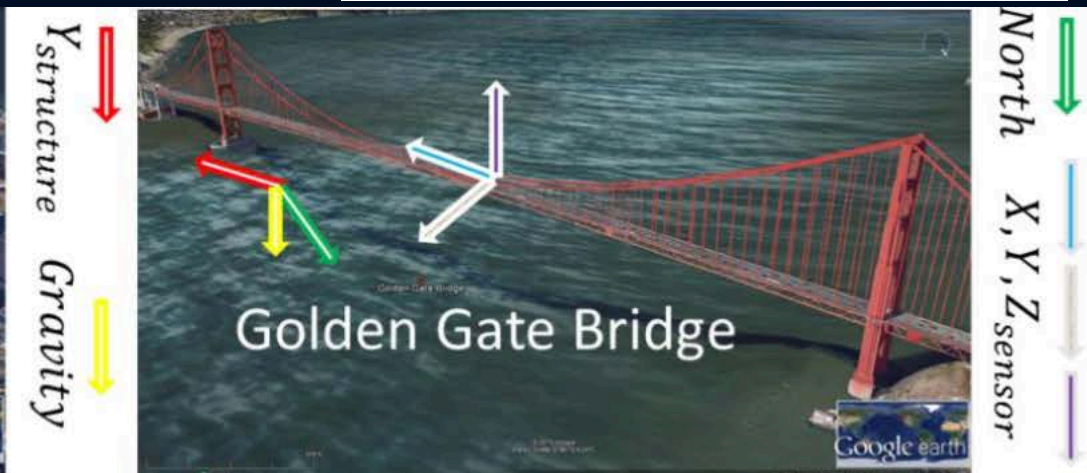




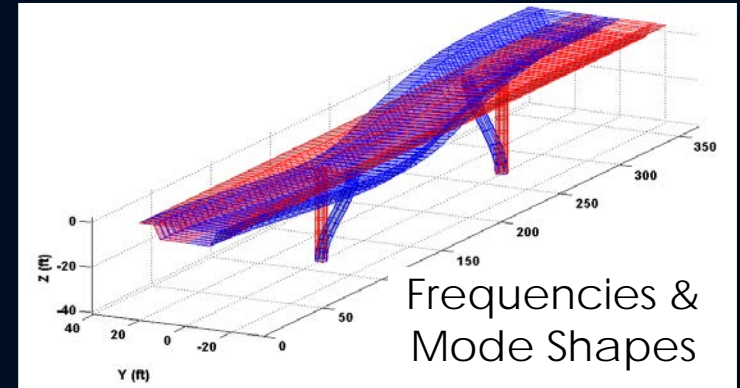
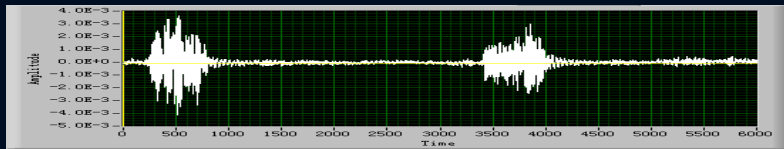
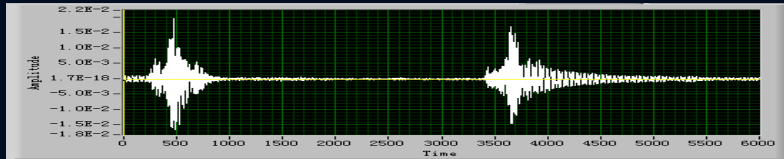
Citizen Sensors



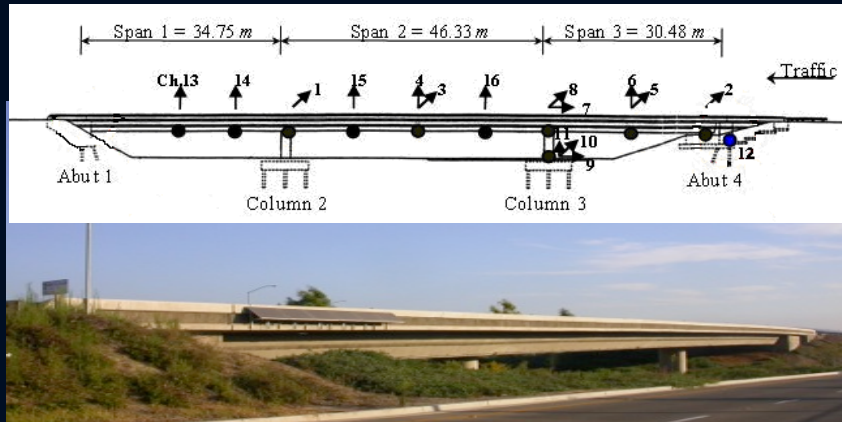
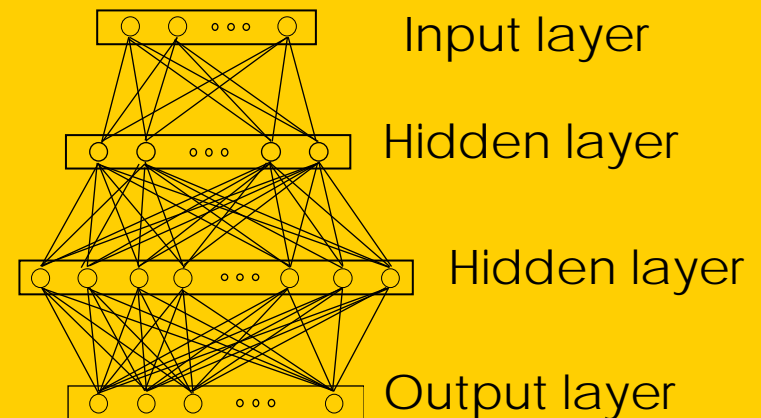
An iOS App



Application of Artificial Neural Networks in SHM



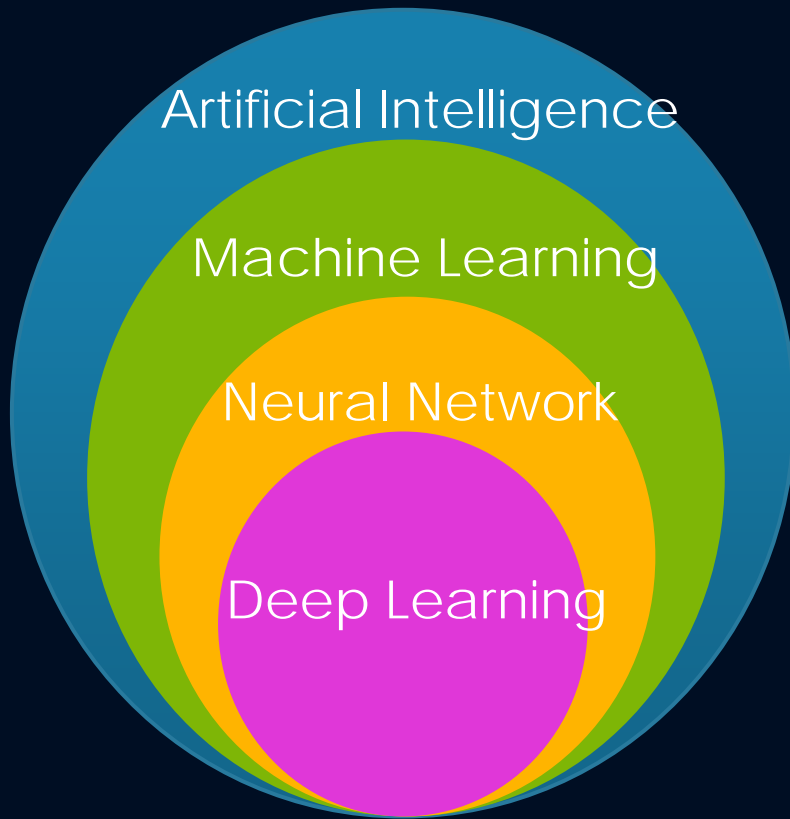
Artificial Neural Network (ANN)



Assessment
of structural
Health

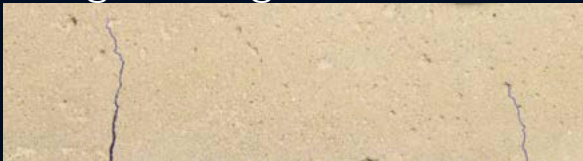
Change of
Stiffness from
Baseline





Applications:

Image recognition



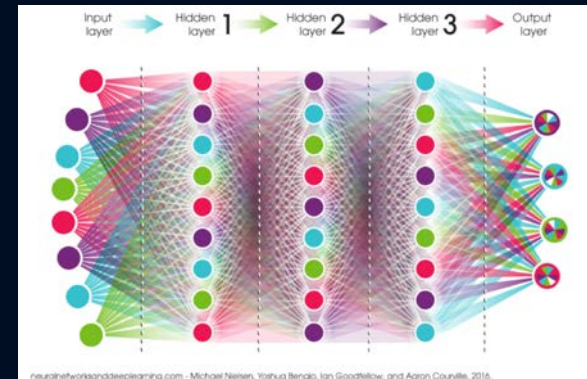
Speech recognition

Neural Network:

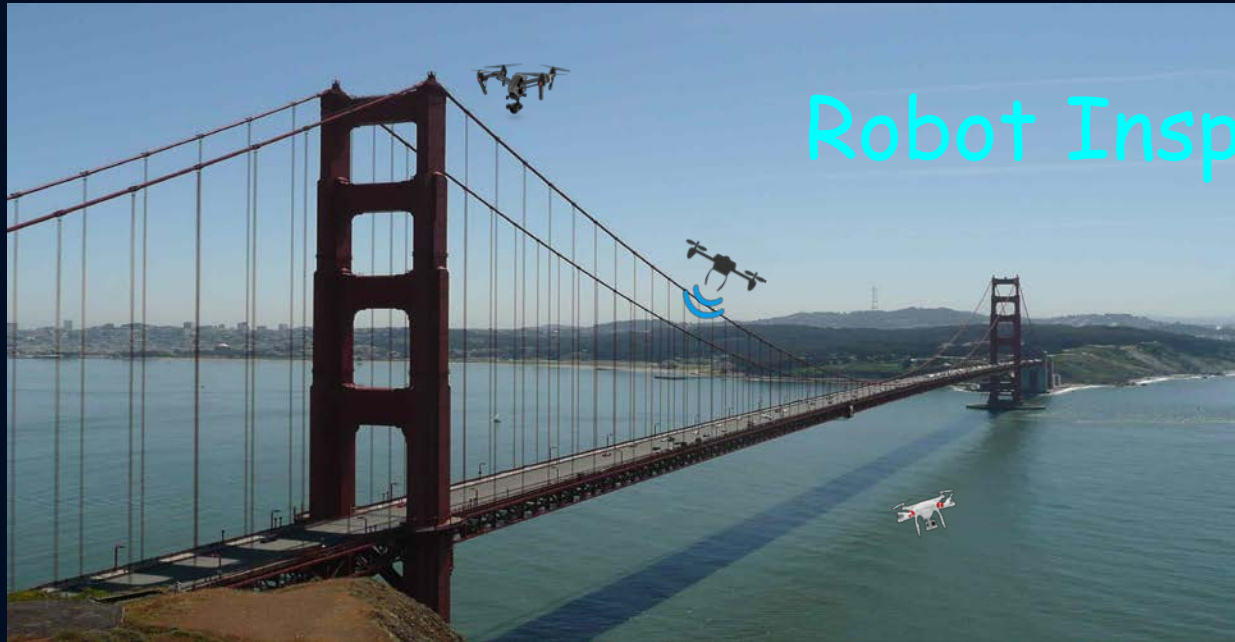


Shallow layers
Supervised learning

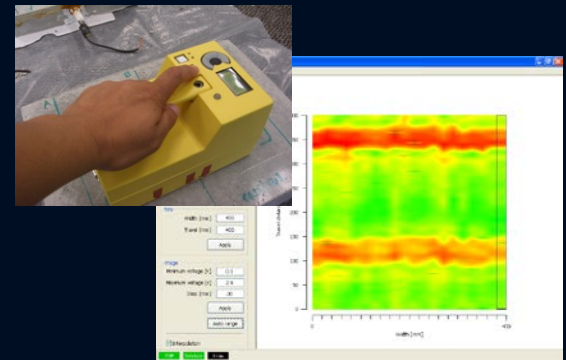
Deep Neural Network:



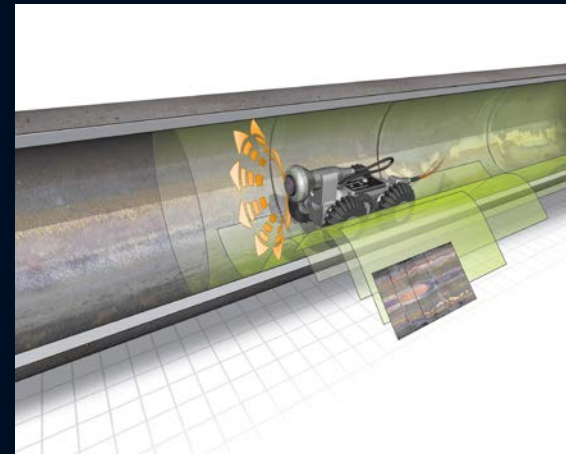
Deep layers
Supervised or unsupervised learning



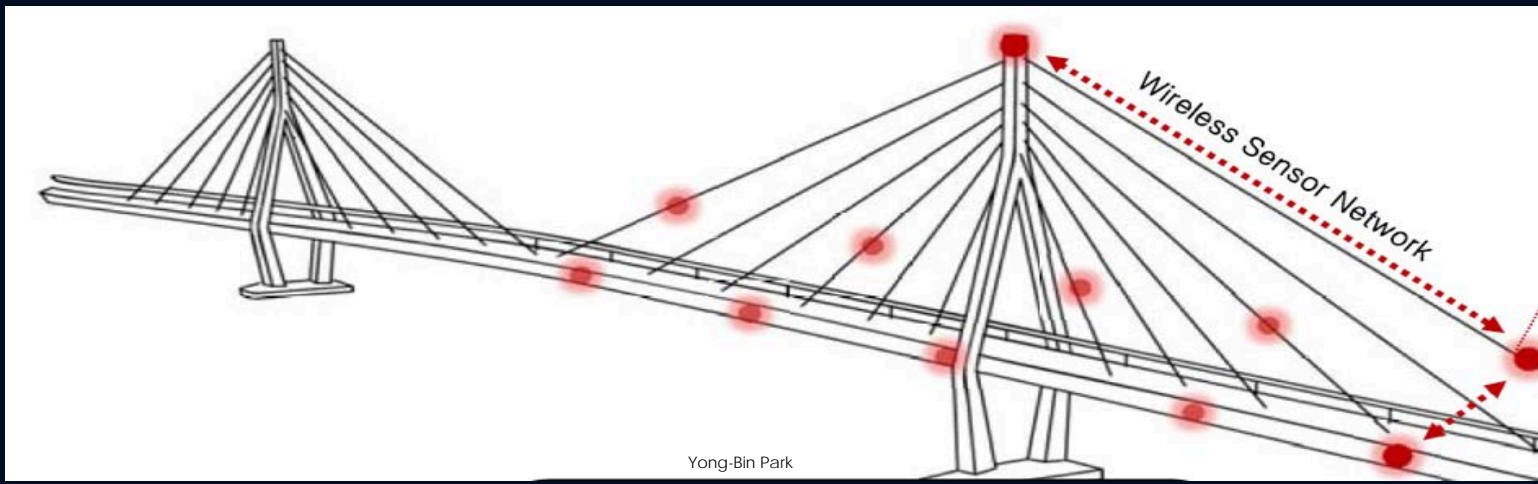
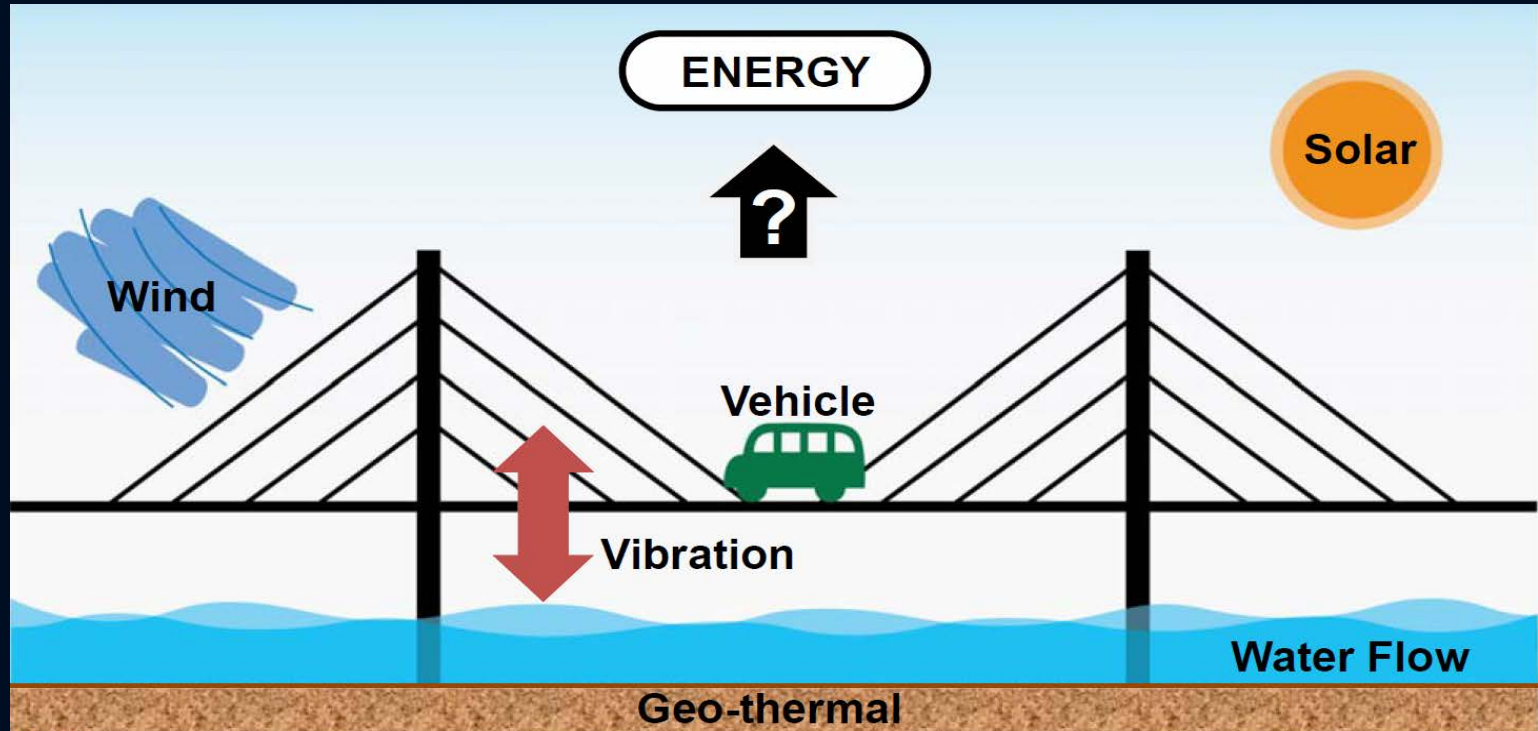
Robot Inspector



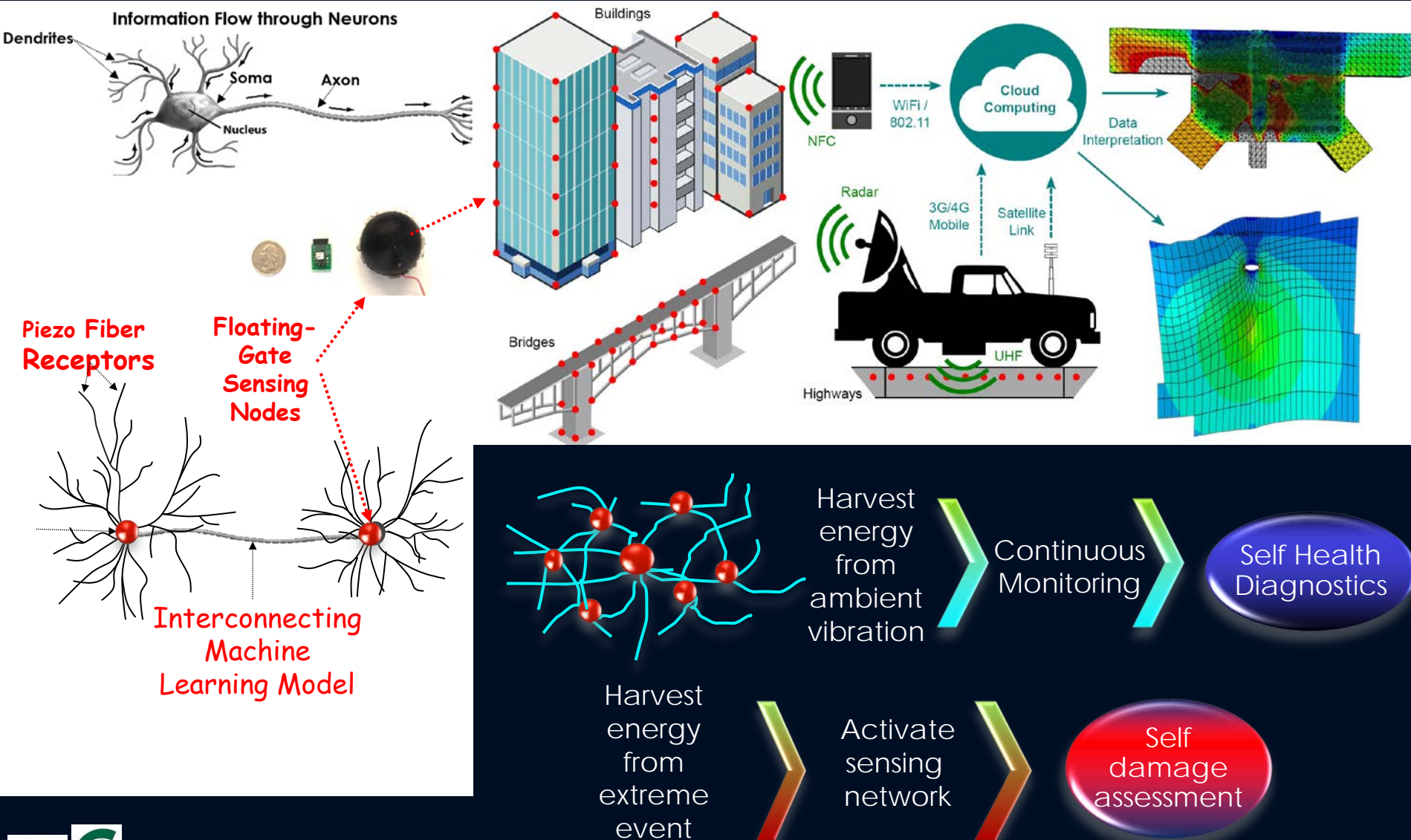
Spider Man



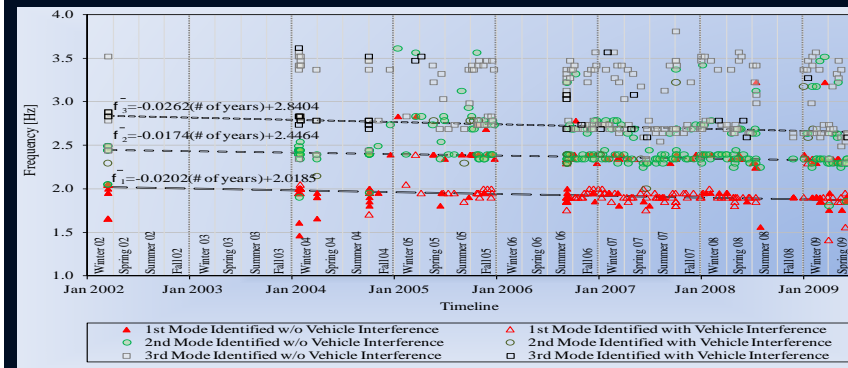
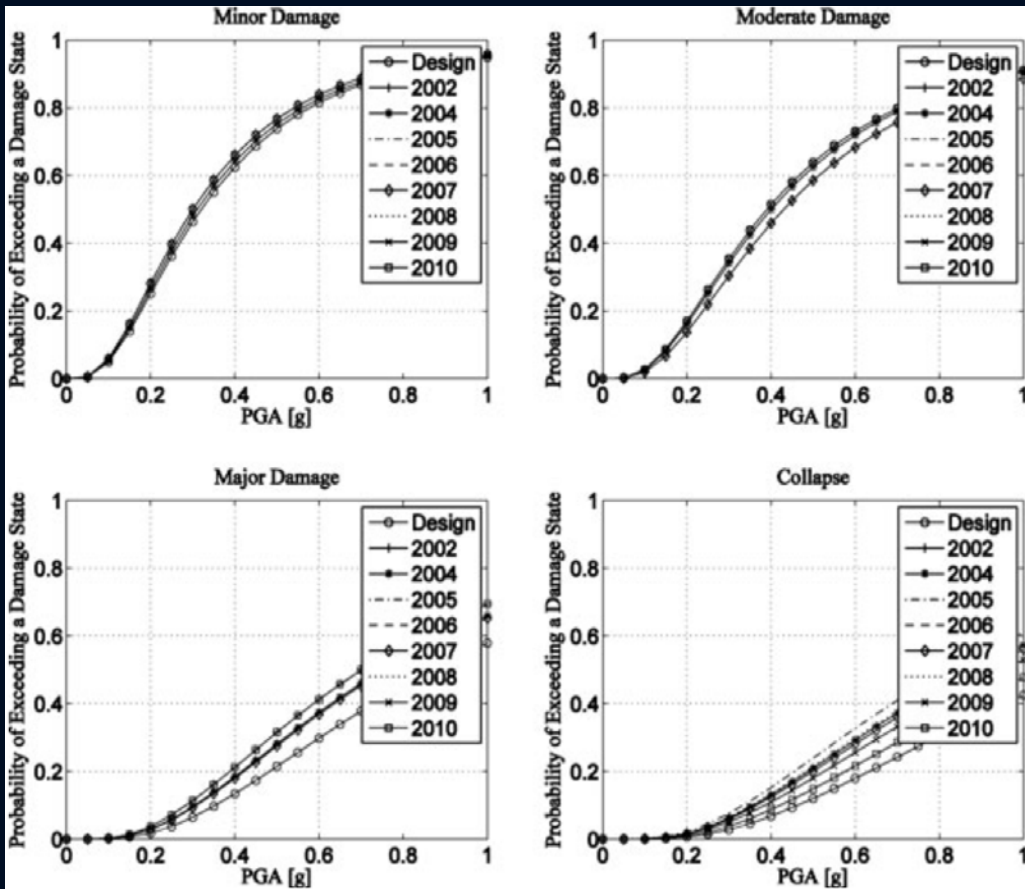
Self-Powered Smart Structure



Bio-Inspired Smart Materials & Structures

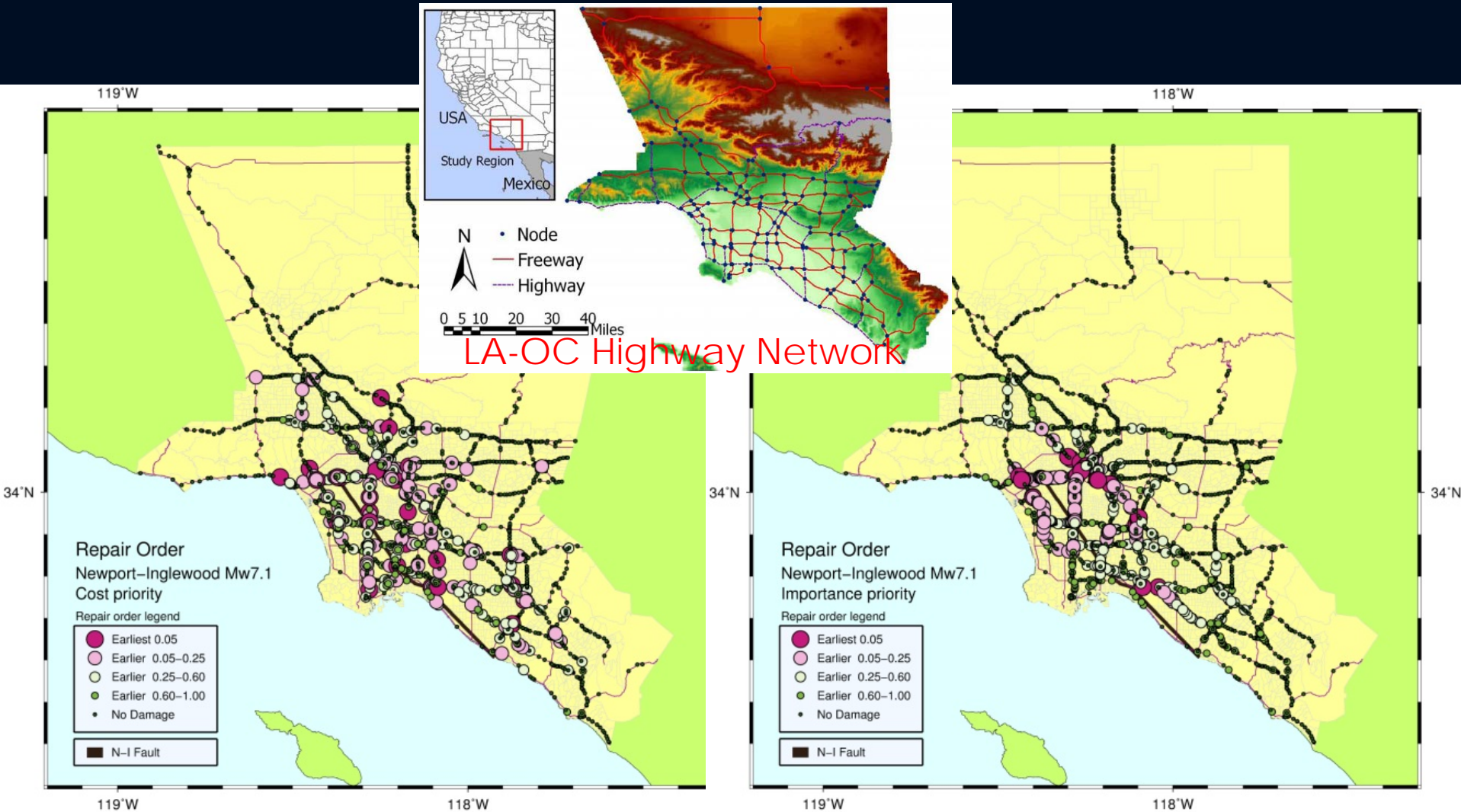


From Diagnostics to Prognostics to Resiliency



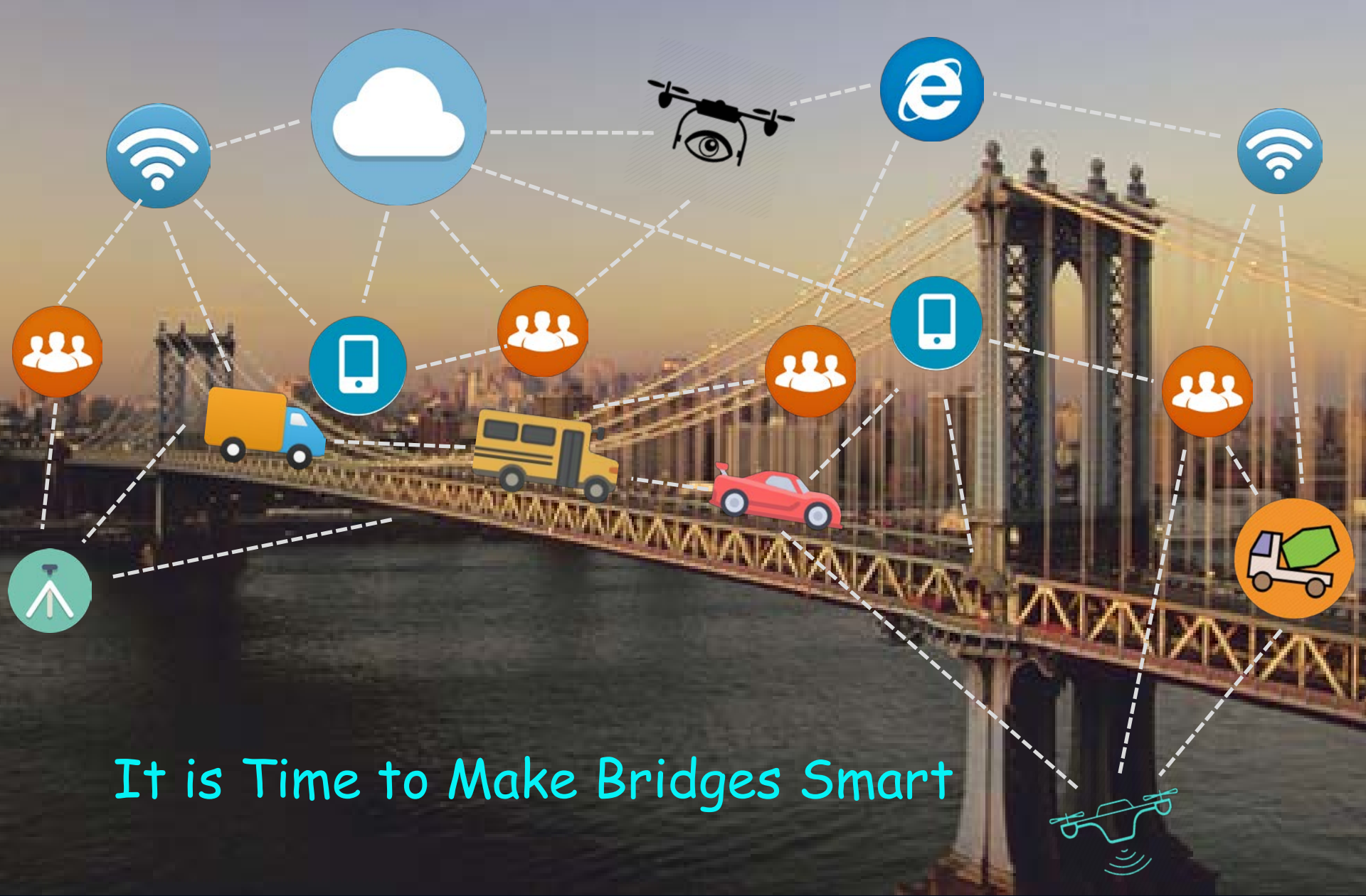
Update **Seismic Fragility** Using 8-Years of Bridge Monitoring Data

From Diagnostics to Prognostics to Resiliency



Repair Prioritization Based on Cost

Based on Importance



It is Time to Make Bridges Smart