Modeling complex physical systems

a data-intensive approach

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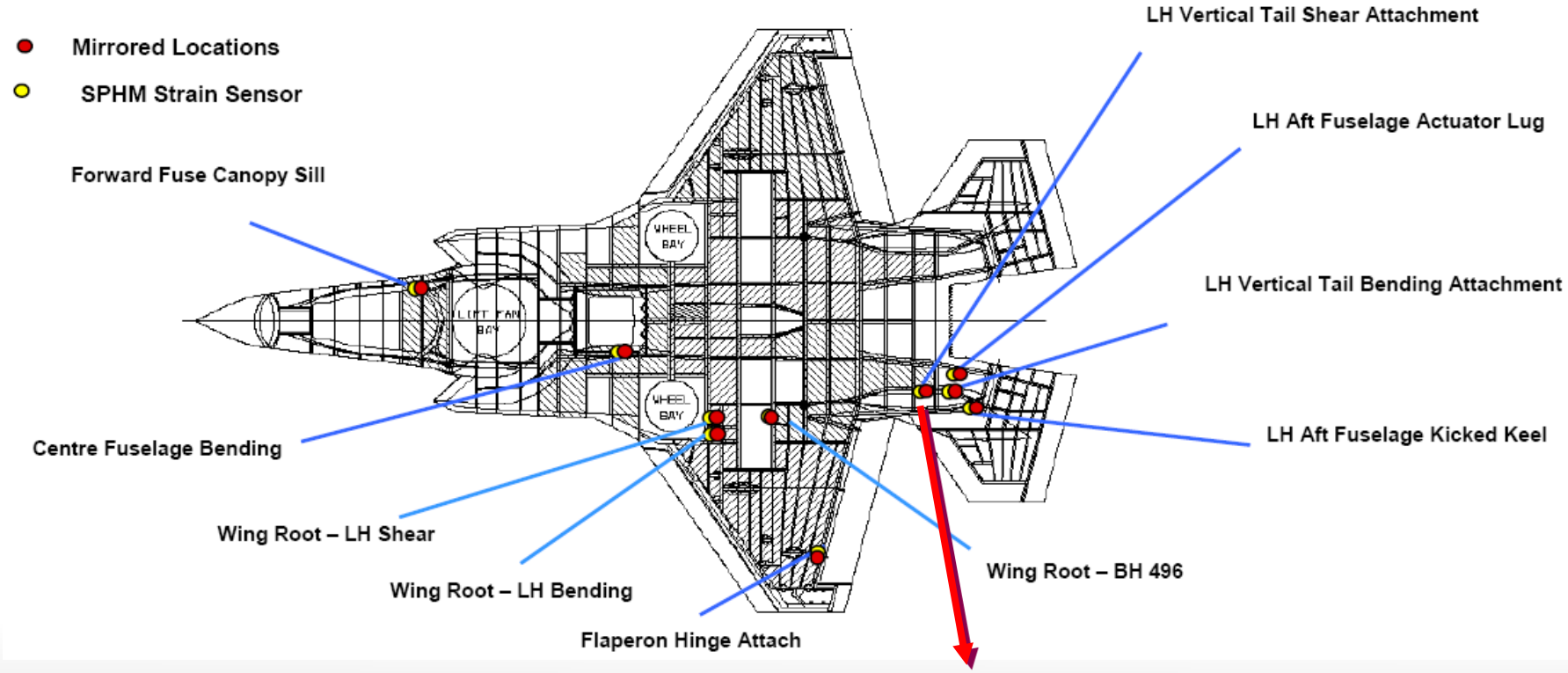

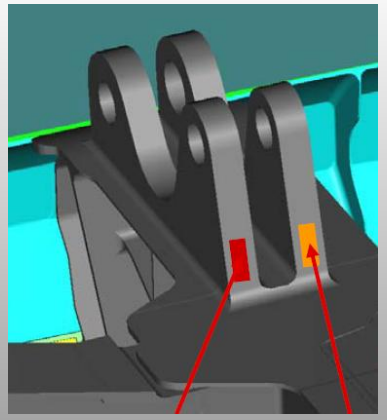

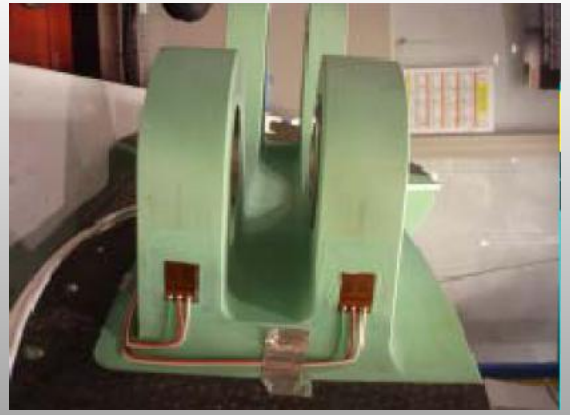

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Structural Health Monitoring

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Structural Health Monitoring

InfraWatch

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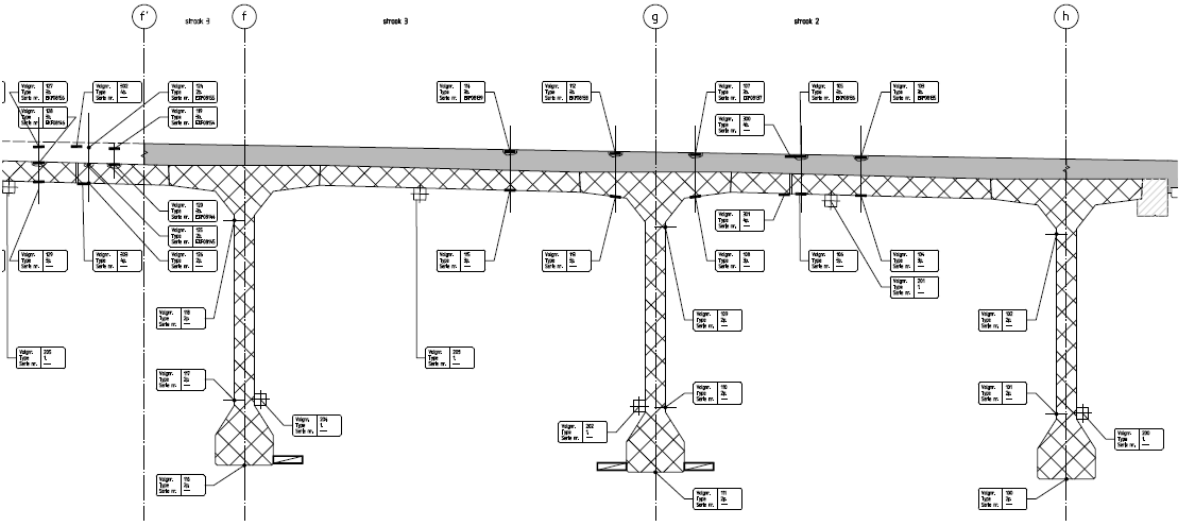
InfraWatch: Hollandse Brug
A6 between Amsterdam and Almere



145 sensors x 100 Hz x 60 seconds x 60 minutes x 24 hours x 365 days = very large number

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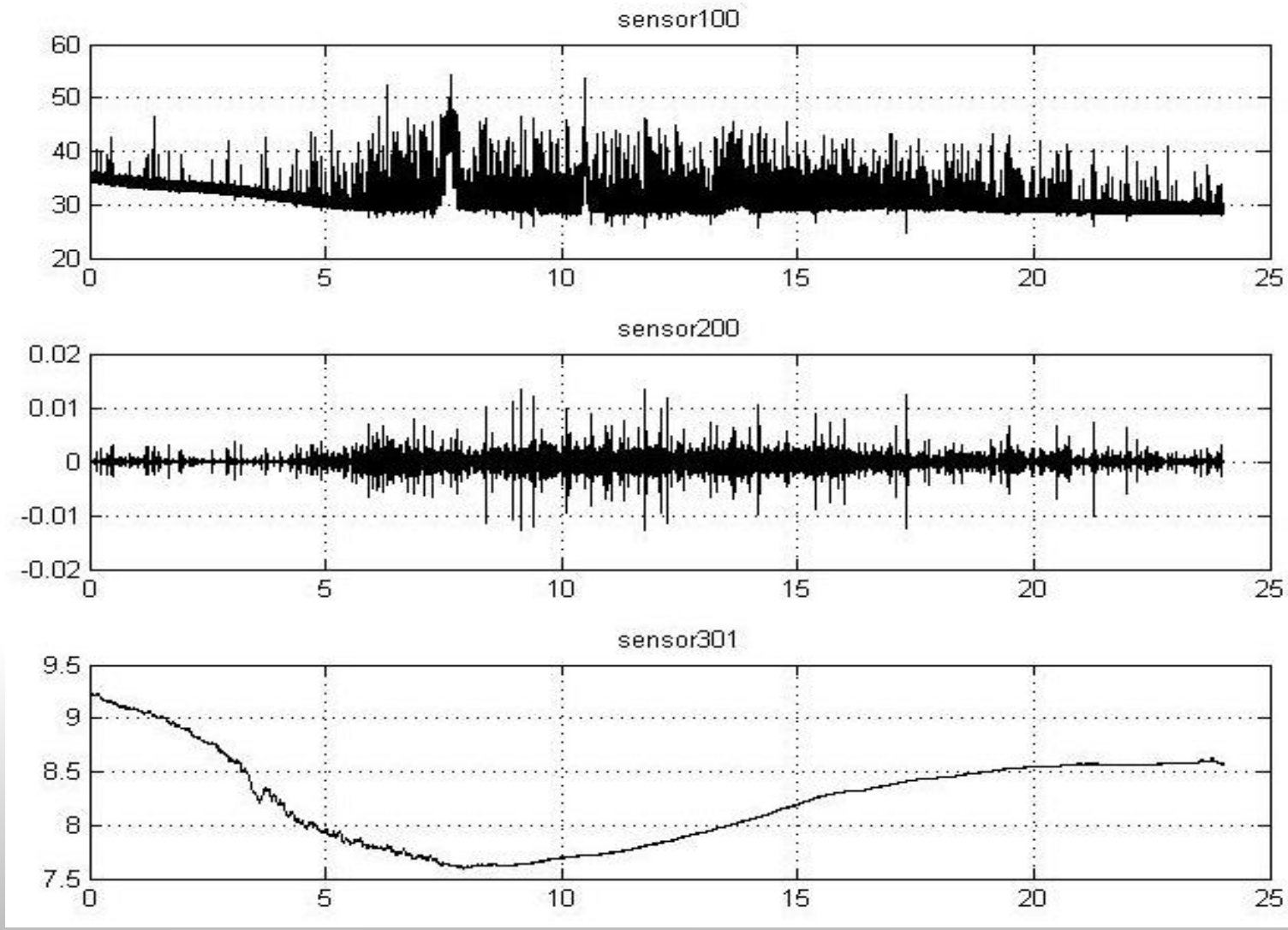
One day of data, multiple sensor types

Strain

Vibration

Temperature



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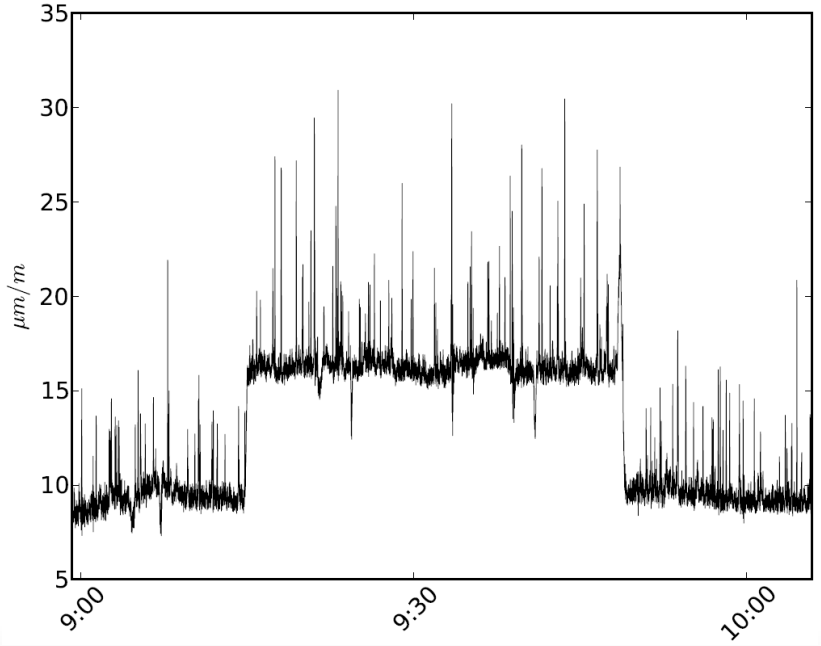
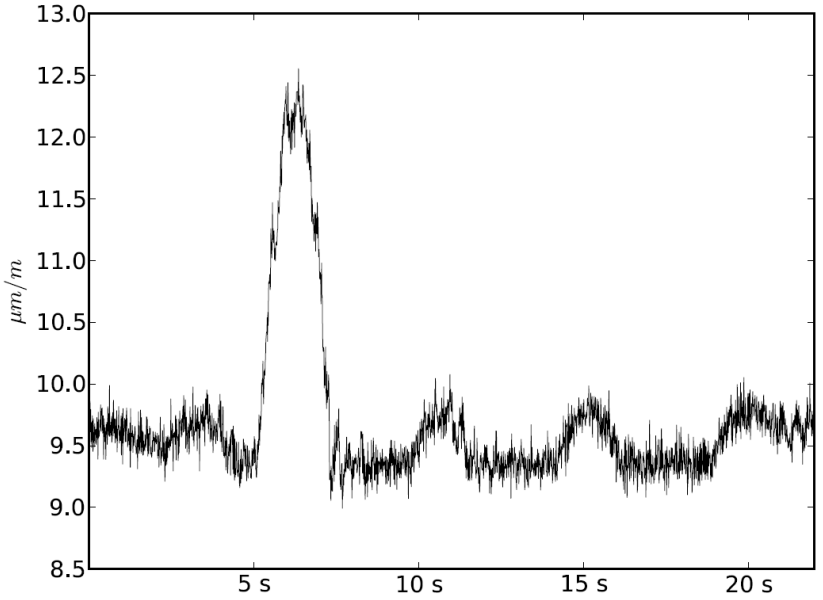
Traffic Events



Traffic Jam



Large Truck + Cars

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Dynamic system

- Bridge is surprisingly dynamic environment
  - constant shaking at 2.8 Hz
  - highly trafficked
  - weather/temperature influence
- On a short time frame (weeks), all events are elastic
  - bridge will respond to traffic, but not permanently
  - temperature will affect bridge, but not permanently
- Gradual change on a long time frame (years)
  - degradation: minute changes will accumulate
  - slow drift in response parameters

How to recognize subtle drift among hectic dynamics

Model response of system

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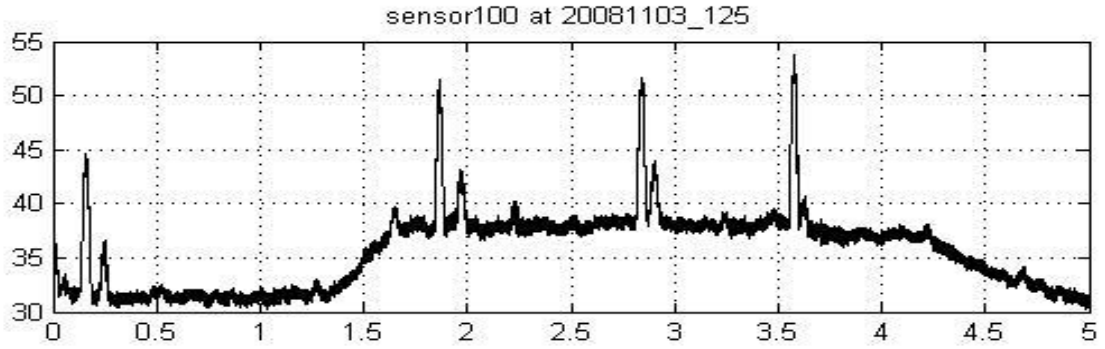
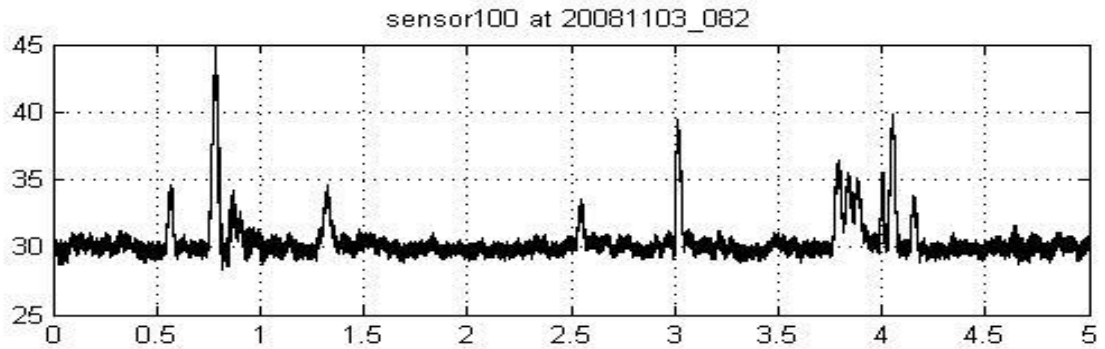
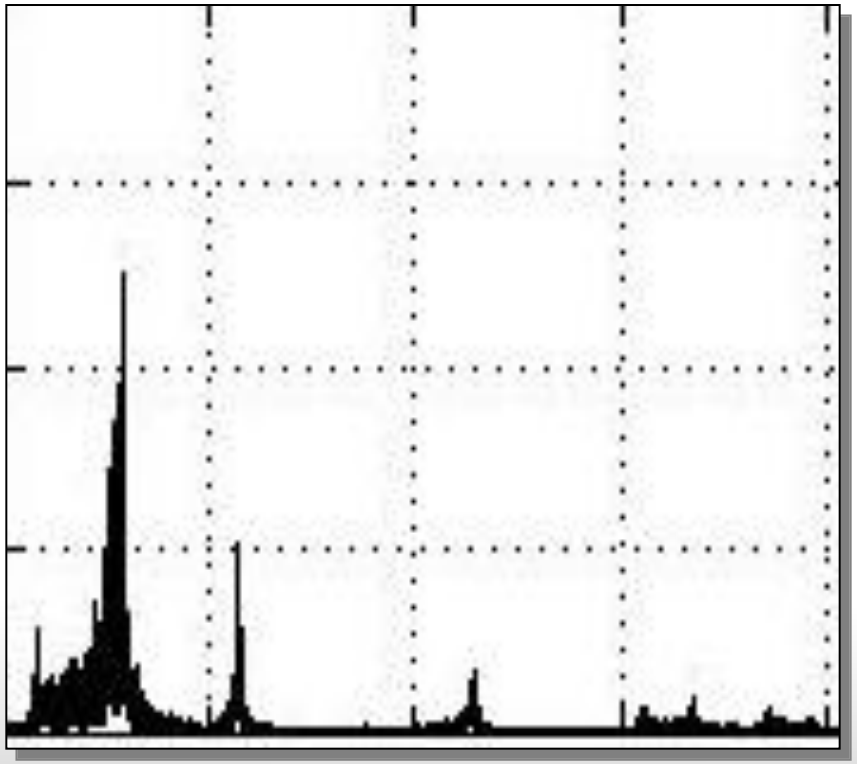
Modeling Bridge Characteristics





Weight determines natural frequency



Spectrum

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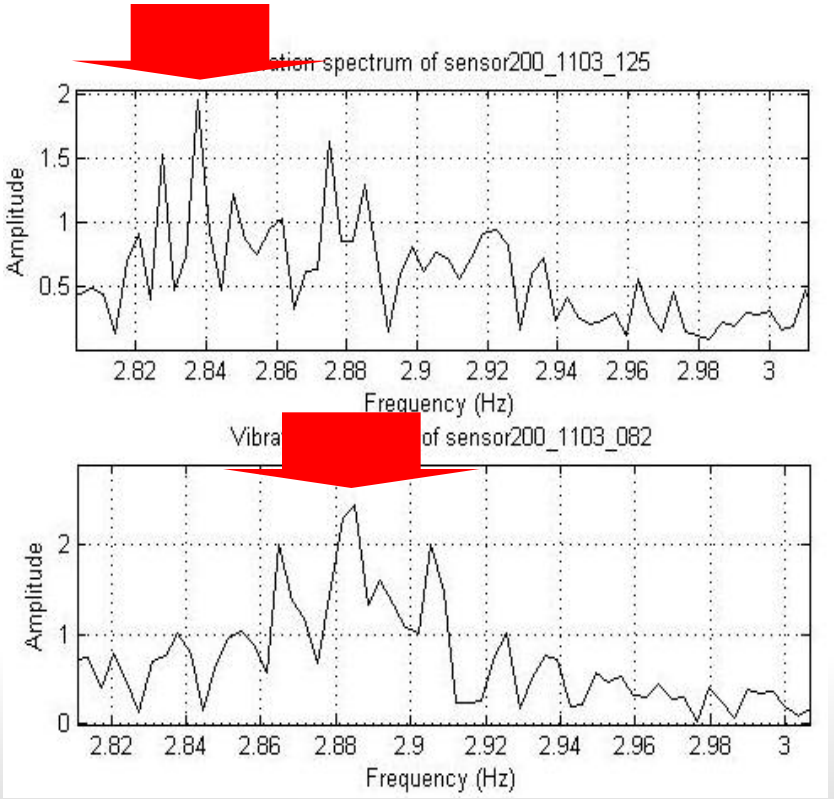
Weight determines natural frequency



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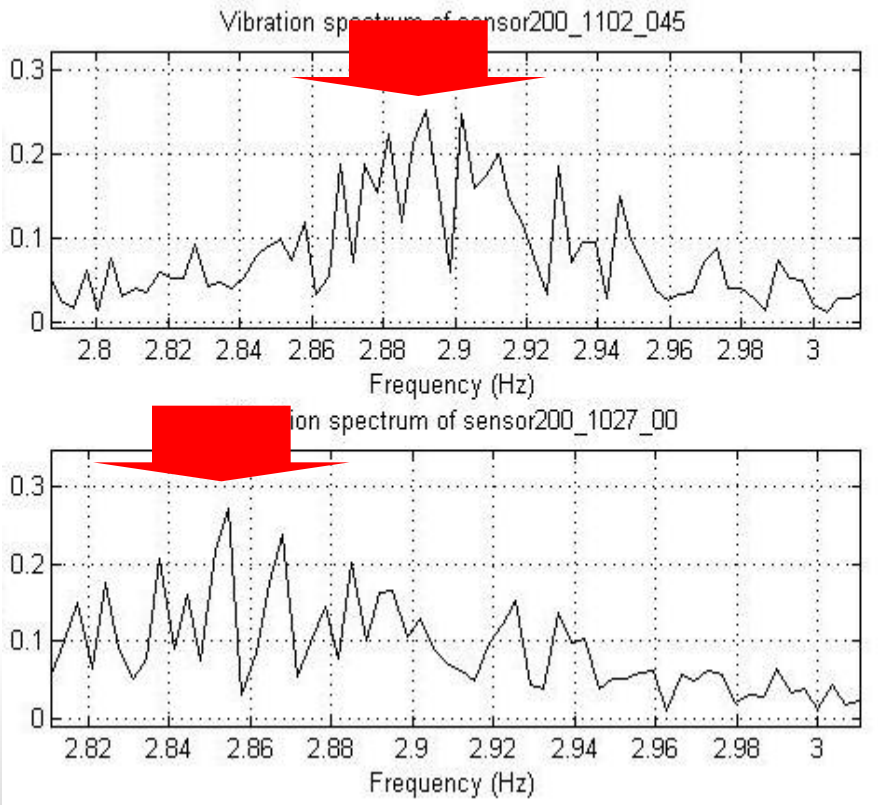
…so does temperature

12.1 °C

6.9 °C



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Modeling response of system

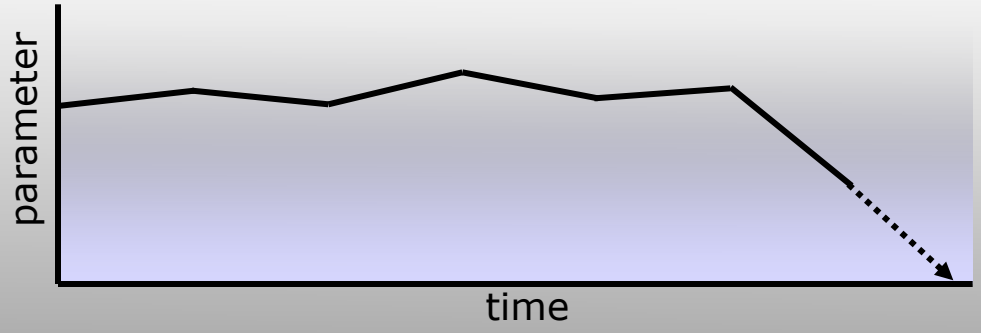
Natural frequency influenced by

- Weight (traffic)
- Temperature

} modeled → accounted for

- Stiffness (‘health’)

- Compare model for two different periods
  - difference in model parameters indicates degradation
- Track model parameters over time



High-Performance Computing at SARA

- Hadoop/MapReduce
  - clustering, signal processing
  - *Big Data*: Disk I/O-bound, rather than CPU
  - test cluster 7×4 processors (much larger in future)
- Grid computing
  - more suitable for CPU-bound problems
  - many operations per chunk
  - e.g. 1 hour of data per node
- Lisa Cluster
  - 4480 cores
  - equation discovery
    - lots of similar operations on same data
  - limited access

Preliminary experiments

- 3 months of data (Hadoop)
  - signal processing
  - clustering
- 6 hours of data (Lisa)
  - equation discovery
  - large search space of models (CPU)
  - validate best model on 1 month

Future:

- More data available, large-scale experiments
- Bigger Hadoop cluster

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Thank you!

www.infrawatch.com

70 Mb of sensor data were collected during this presentation

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