Cyber Infrastructure for Bridge Lifecycle Monitoring

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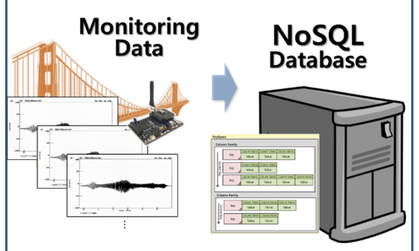
Introduction

The goal of this research is to create a cyber physical infrastructure framework for bridge monitoring and management. While most structural health monitoring research studies focus on new sensing and monitoring technologies, little efforts have been spent on the fundamental data issues. The data issues need to be dealt with before sensing technologies can truly find useful for bridge lifecycle assessment and management. Our initial task is to establish a cyber infrastructure for bridge monitoring system to support integrated data management, to enable diagnosis of potential structural problems, and to facilitate prognosis for the need of structural strengthening and repairs. NoSQL database systems are employed for scalability and schema flexibility. Data schemas for sensor data and bridge information model are defined and interfaces are being developed to connect the database systems with data analyses. In addition, sensor data and bridge information are linked together so that measured responses can be easily compared with the analytical results.

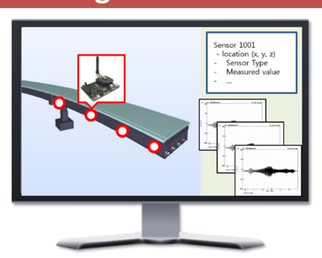
Research Objective

Cloud based Bridge Sensing Data Management



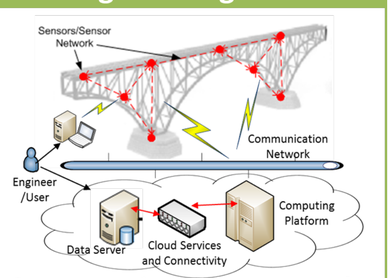
NoSQL database technologies to facilitate managing bridge monitoring data

Integrated Technology of Sensing Data and BrIM



Ontology and data schema for sensor information and bridge information model (BrIM)

Framework for Lifecycle Bridge Management

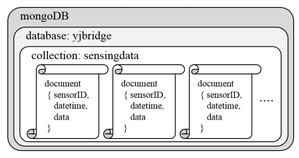


Computational framework to support bridge management and lifecycle assessment analysis.

Cyber Infrastructure Framework

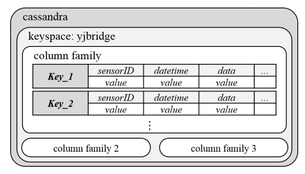
DB system for efficient querying

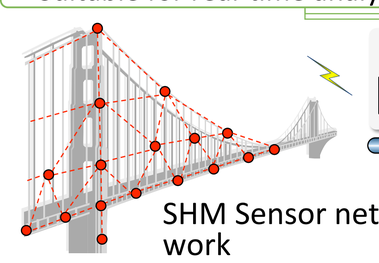
- MongoDB
- Schema free structure
- Strong query capability
- Suitable for real-time analysis



DB system for efficient archiving

- Apache Cassandra
- Flexible schema
- High scalability
- Suitable for high volume data repository





SHM Sensor net work

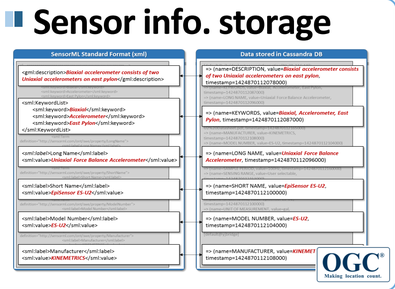
On-site computer
- Data pre-processing
- Temporary storage

Local computer
- Computing platform
- Data analysis

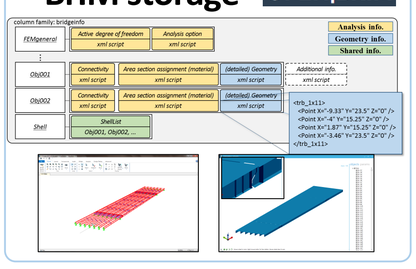
End users
- Retrieve data via web-interface

Central server
- Persistent repository of sensor data
- Bridge information model storage
- Analysis result storage

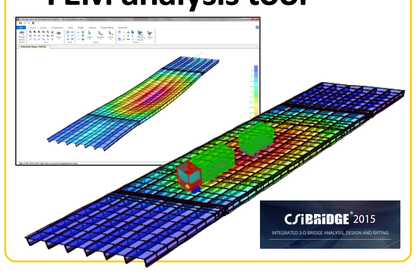
Sensor info. storage



BrIM storage OPEN|BRIM



FEM analysis tool



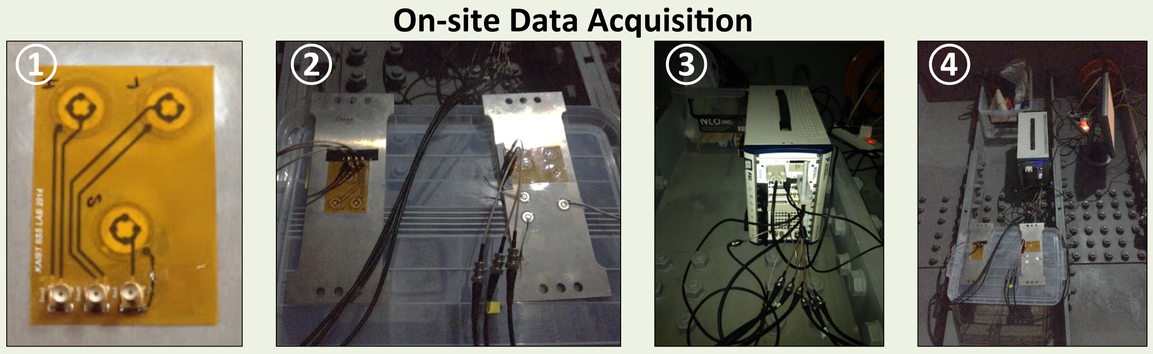
Features

- Real-time, seamless dataflow from the sensor network to central server
- Robustness against unstable network connection and unstable power supply
- Compatibility with “old” sensing devices
- Interoperability with bridge information model and automatic model conversion
- Integration of sensor data (sensorML) with BrIM and bridge management system

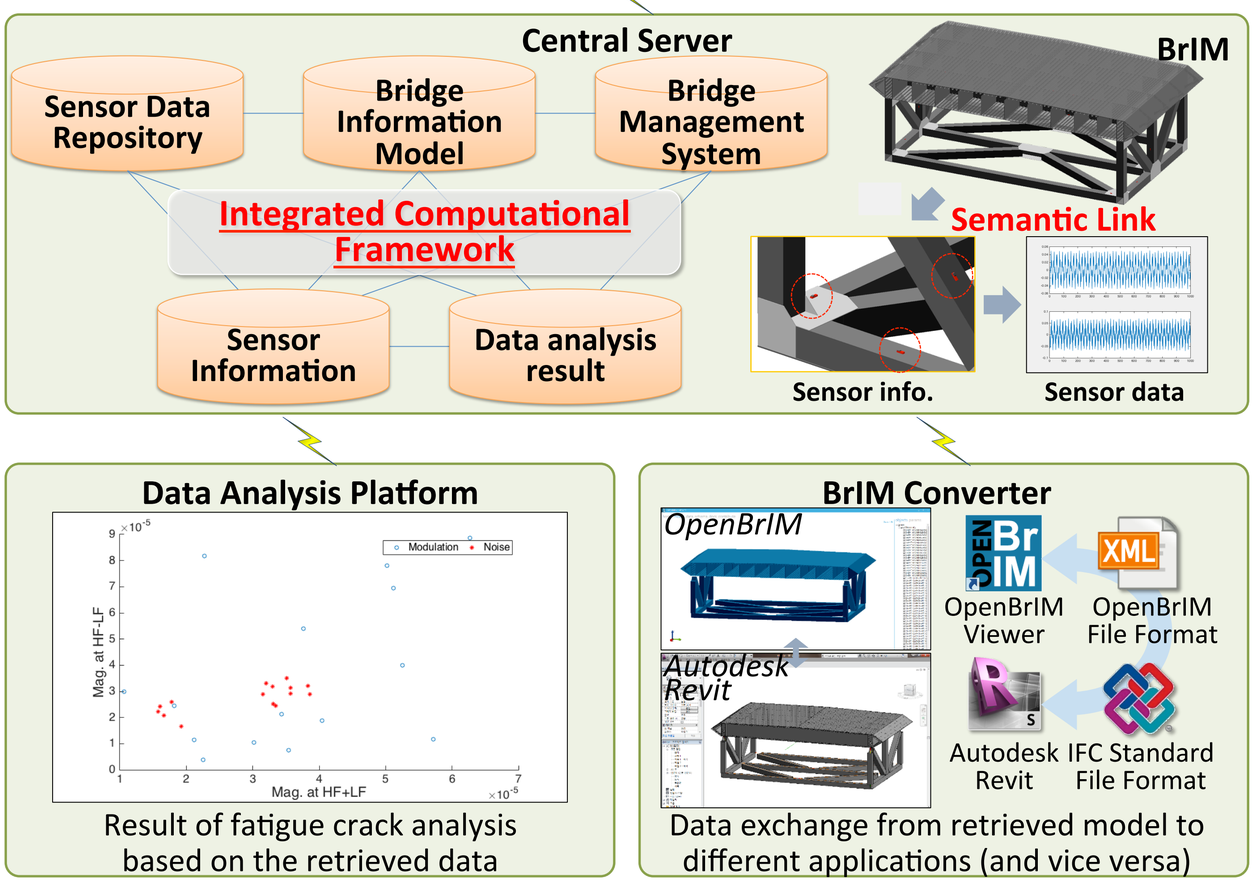
Yeongjong Bridge

- Real-time data transmission from sen sors on Yeongjong bridge to central se rver at KAIST
- Data analysis using sensor data onsite and remotely from central server
- Bridge model conversion between Op enBrIM and Autodesk Revit (CAD soft ware)
- 2 fatigue crack sensors
- Sampling rate: 1Mhz

On-site Data Acquisition

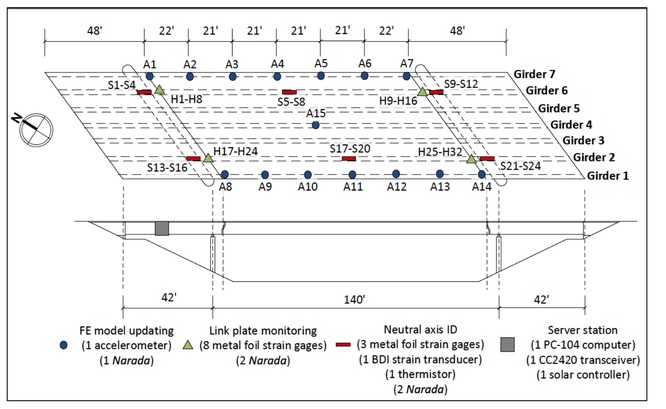


① Fatigue crack sensor ② Damaged & undamaged specimens ③ On-site computer (NI-PXI) ④ On-site system



Telegraph Road Bridge

Telegraph Road Bridge, MI, USA

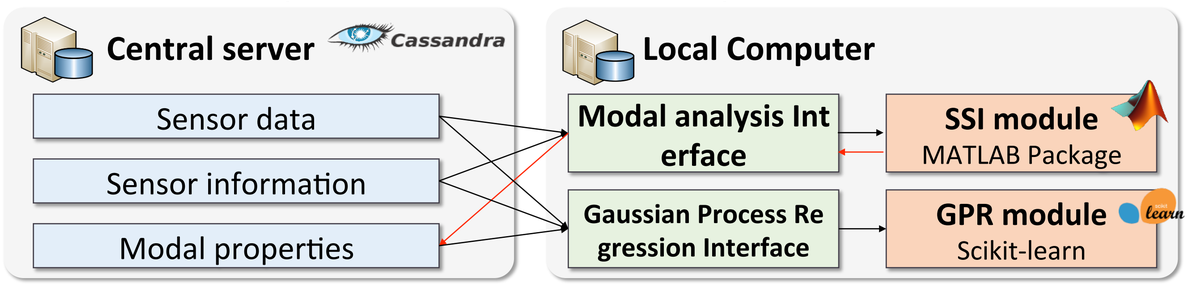


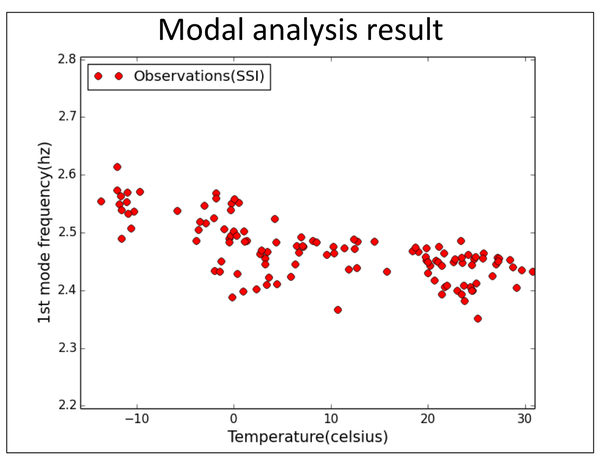
Sensor layout

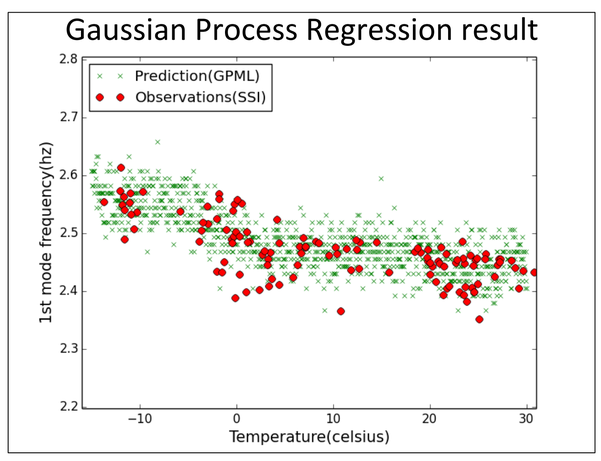
- 14 accelerometers, 40 strain gauges, and 6 thermistors.
- Data was acquired every 2 hours for one minute time duration.
- Sampling rate: 200Hz (accelerometer), 100Hz(strain gauge and thermistor)

Gaussian Process Regression

- Seven weeks of sensor data (one week per month from Aug. 2014 to Feb. 2015)
- Stochastic Subspace Identification (SSI) algorithm (output-only modal analysis)
- GPR module returns predictive model for natural frequencies.







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