41 R&D of Integrated Data Management Platform for Civil Infrastructure Sensing

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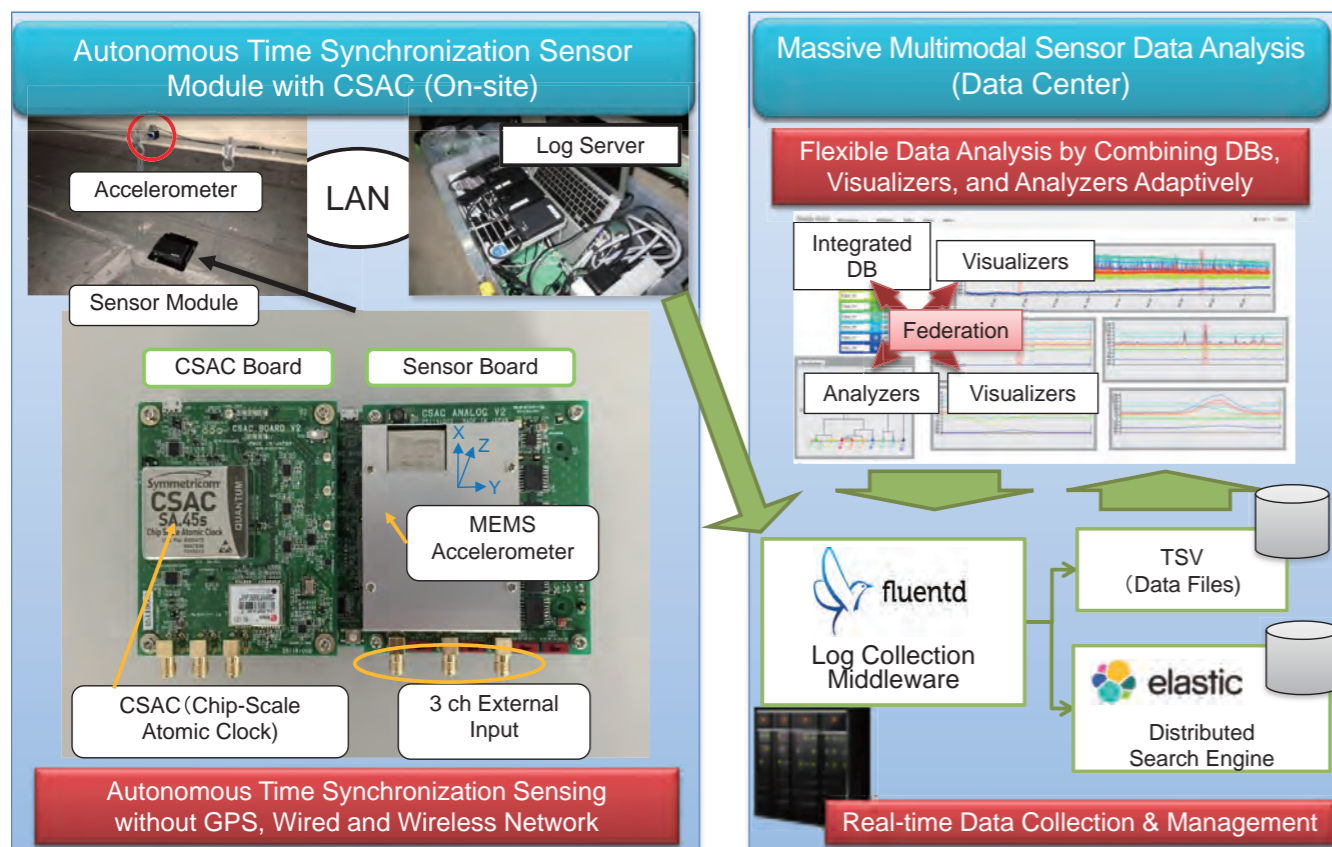
R&D Objectives and Subjects

Objectives

❖ **Data Management Technologies** : to develop efficient multimodal monitoring data management technology for analyzing, storing and utilizing massive data.

❖ **Analysis Technologies** : to extract features that may reflect structural deformation for defining new structural-deformation indices through the collaboration between structural analysts and data scientists.

❖ **Time Synchronization Sensing Technology** : to develop multimodal sensing technology for integration of various sensors with autonomous time synchronization.

Subjects

❖ R&D on an exploratory visual analytics environment that integrates varieties of analysis and isualization tools with database systems.

❖ Accurate vehicle detection and feature extraction related to structural deformation of bridges by combination of frequency analysis, signal processing and data integration technologies.

❖ R&D on a multimodal sensing module with an autonomous time synchronization using Chip-Scale Atomic Clock (CSAC) that integrates various sensors.
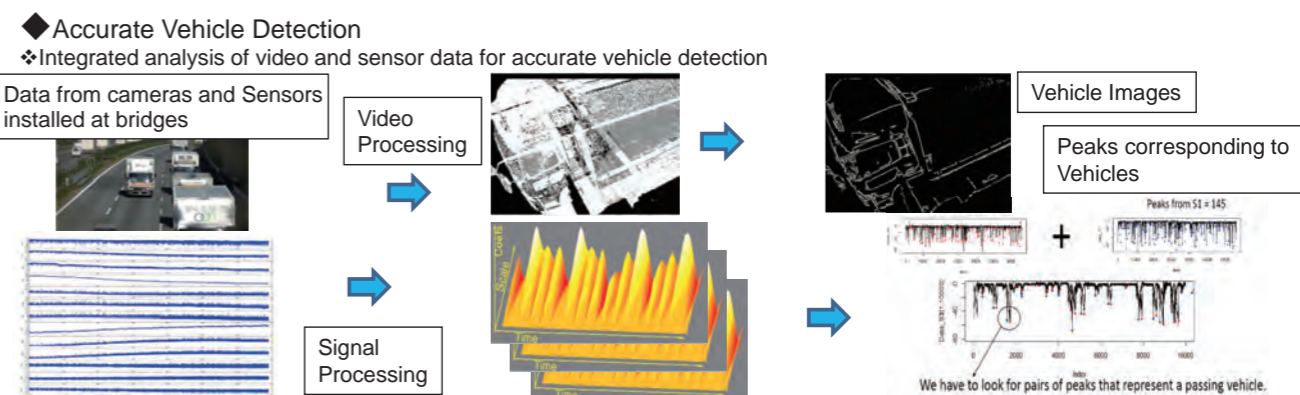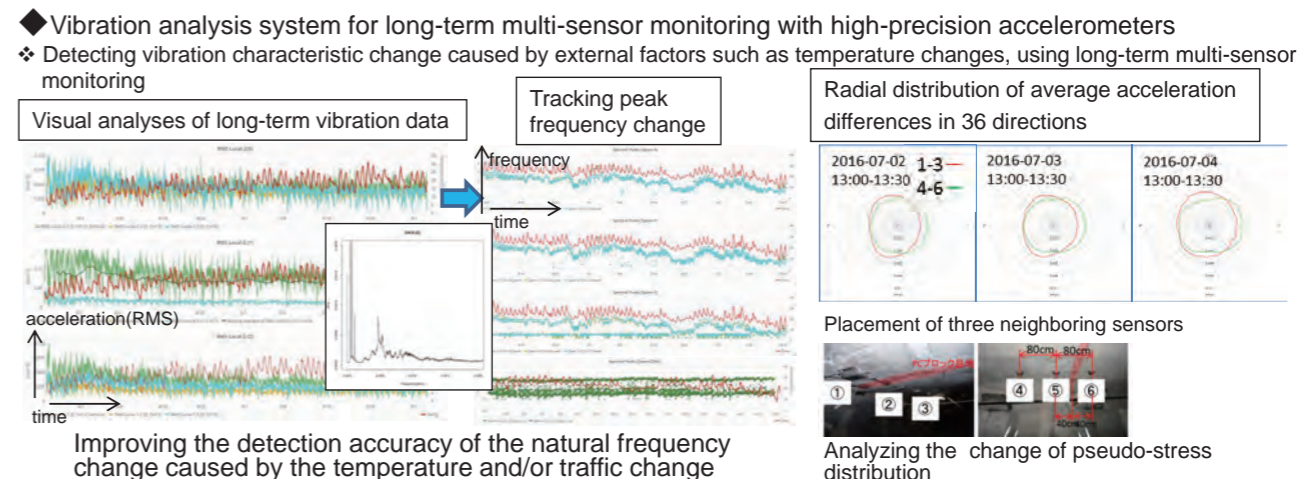
Current Accomplishments (1/2)
— Data Management Platform —

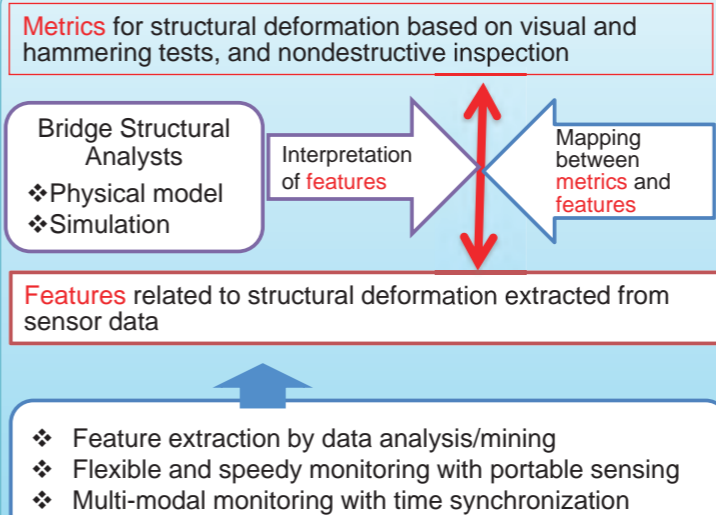Autonomous Time Synchronization Sensor Module with CSAC (On-site)
Accelerometer — LAN — Log Server
Sensor Module
CSAC Board — Sensor Board
MEMS Accelerometer
CSAC (Chip-Scale Atomic Clock) — 3 ch External Input
Autonomous Time Synchronization Sensing without GPS, Wired and Wireless Network

Massive Multimodal Sensor Data Analysis (Data Center)
Flexible Data Analysis by Combining DBs, Visualizers, and Analyzers Adaptively
Integrated DB — Visualizers — Federation — Analyzers — Visualizers
fluentd — Log Collection Middleware
TSV (Data Files)
elastic — Distributed Search Engine
Real-time Data Collection & Management

Current Accomplishments (2/2)
— Sensor Data Analysis —

◆Vibration analysis system for long-term multi-sensor monitoring with high-precision accelerometers
❖ Detecting vibration characteristic change caused by external factors such as temperature changes, using long-term multi-sensor monitoring

Visual analyses of long-term vibration data
Tracking peak frequency change
Radial distribution of average acceleration differences in 36 directions
2016-07-02 13:00-13:30 1-3 4-6
2016-07-03 13:00-13:30
2016-07-04 13:00-13:30
acceleration(RMS)
frequency
time
Placement of three neighboring sensors
Improving the detection accuracy of the natural frequency change caused by the temperature and/or traffic change
Analyzing the change of pseudo-stress distribution

◆Accurate Vehicle Detection
❖Integrated analysis of video and sensor data for accurate vehicle detection

Data from cameras and Sensors installed at bridges
Video Processing
Signal Processing
Vehicle Images
Peaks corresponding to Vehicles
Peaks from 51 = 145
We have to look for pairs of peaks that represent a passing vehicle.

Goals
— toward efficient road management —

Bridge Management Support

Metrics for structural deformation based on visual and hammering tests, and nondestructive inspection
Bridge Structural Analysts ❖Physical model ❖Simulation — Interpretation of features — Mapping between metrics and features
Features related to structural deformation extracted from sensor data
❖ Feature extraction by data analysis/mining
❖ Flexible and speedy monitoring with portable sensing
❖ Multi-modal monitoring with time synchronization

Output

Sensing data analysis for supporting road maintenance planning
• DB prototype system for managing various infrastructure maintenance data
• Accurate bridge-weigh-in-motion
• Metrics and use guidelines for sensing data analysis

Promotion of Developed Systems

Multi-sensing technology by autonomous time synchronization
Technical specifications of sensor module that can be commercialized

Open source software for integrated sensing data management, visualization and analysis
① Open package software
•Publish integrated software
② Open software libraries easily portable to other systems
•DB system modules, data visualization libraries
•BWIM libraries, feature extractor for structural deformation detection
•Expansion of sensors and data formats
•Tutorial, manuals

Promote software usage by publishing modules and libraries with a commercially usable license (e.g., Apache 2.0, New BSD license)