11 R&D of learning-type hammering echo analysis technology

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R&D Objectives and Subjects

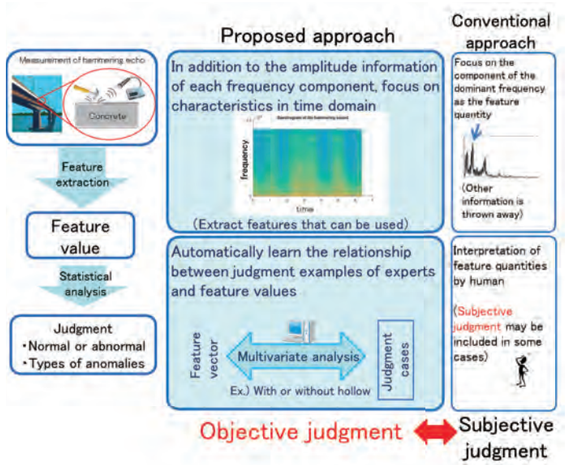
Objectives

- Improvement of hammering echo device as the first stage of inspection
  - —Easy and Reliable
  - —High precision (detection of damage in difficult areas even by experts)
  - —Reduction of total man-hours, including report preparation
- Realization of quantification and accumulation of hammering inspection results, and their visualization

Subjects

- Digitalization of hammering echo, and anomaly detection by its collection and analysis
- Using acoustic signal analysis based on machine learning, automatically distinguish hammering echo differences and detect damaged parts of structures
- Develop a device which is usable in combination with an ordinary inspection hammer, validate the proposed approach in an actual structure

Hammering echo signal analysis based on machine learning



Current Accomplishments (1/2)

Learning in two stages

- Even at the phase where data with supervised labels is not sufficiently gathered, the presence or absence of anomalies can be judged at the first stage
- Corresponds to the differences of the hammering echoes triggered within various structure types
- Applicable toward any hammering equipment by **virtue of its versatility**

First stage: unsupervised learning method

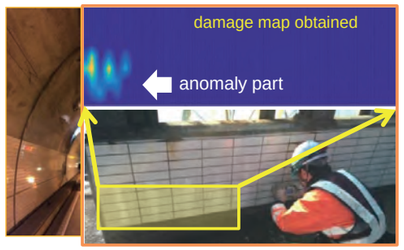
- Learn what is “normal” on site for each structure under examination
- Define the degree of anomaly as deviation from the learned “normal”
- Calculate the degree of anomaly for each hammering point

Second stage: supervised learning method

- Accumulate the judgment results in the first stage with **supervised labels**
- Decision learning based on accumulated results
- Improve decision accuracy of presence / absence of anomaly

Validity verification experiment on a tile-hitting echo test in a tunnel

Hitting echo test device using a probe rod



Even in a noisy tunnel it was possible to reliably find an area where some tiles are floating

Confirm that it is an extremely noise-resistant method of analysis

Current Accomplishments (2/2)

Development of a hammering device for difficult-to-inspect points

- For hammering of unreachable areas in abutments, piers, etc.
- Detection of internal defects in concrete, not only the exfoliated areas
- Reduction of man-hours for scaffold installation

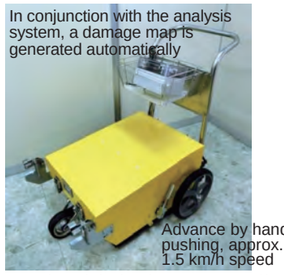
- Uses a solenoid for hammering actuator
- Introduces a mechanism that allows the part hitting the surface lines up well with the target
- Used in conjunction with automatic trace acquisition system of hammering (under development)

Evaluating experiments for test pieces and actual bridges of local governments

Development of handcart-type hammering device

- Grasping damage conditions of the floorboards before pavement excavation (non-destructive investigation)
- Detection of slab deterioration or cracks in the asphalt pavement surface
- Reduction of man-hours and excavation costs of hammering echo investigation

Current manual hammering echo inspection



Developed device (prototype ver. 2)

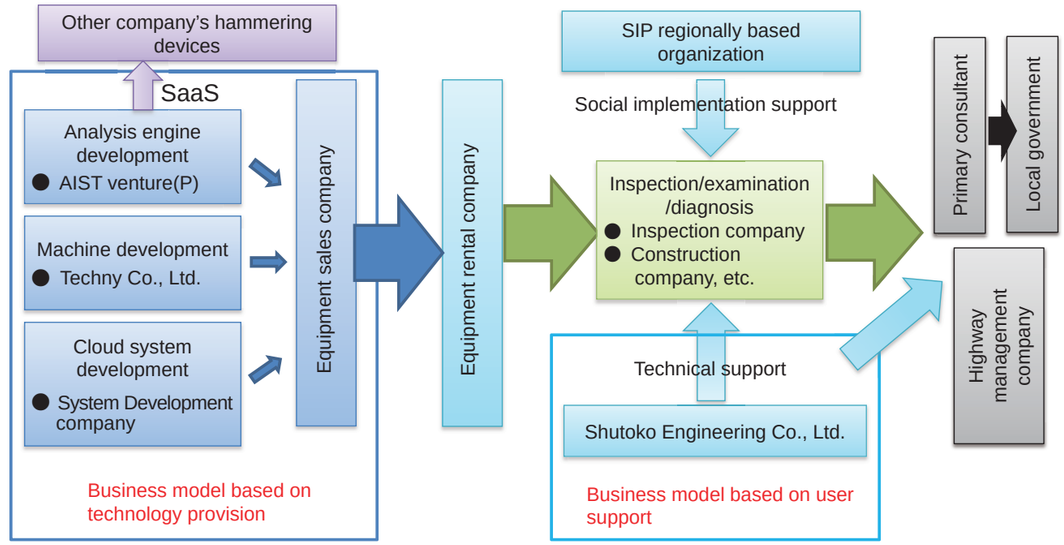
Evaluating experiments for actual bridges of the Tohoku expressway and test pieces

Validation of anomaly detection points by core removal in a floorboard just before replacement

Horizontal crack in an existing floorboard

Interface fracture between thickening part and floorboards

Goals



① Set up a development system that continually improves the technology

② Deploy the developed equipment with technical consulting / support from SIP regional bases

③ Provide an analysis engine as SaaS (Software as a Service)

- Intensive system administration and operation
- Stable supply of services and permanent upgrade