48 R&D of Flying Robot for Bridge/Tunnel Inspection

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R&D Objectives and Subjects

Objectives

Develop alternative system for infrastructure inspection utilizing a flying robot with hammering test equipment

Problems with the conventional inspection method
① Road closure during inspections
② Difficulties with inspecting high areas
③ High risks for human inspectors

Utilization of flying robot
① Reduction of road closure time
② Easier access to remote areas
③ Less risk during the inspection

Bridge and tunnel environment

Flying robot under development

Hammering test equipment

Research Topics

① Development of flight control technology to cope with **GPS-denied and highly windy environments**
② Research of **inspection technology for concrete structures using hammering test equipment**
③ Research of effective ways of inspection in terms of **safety and time**
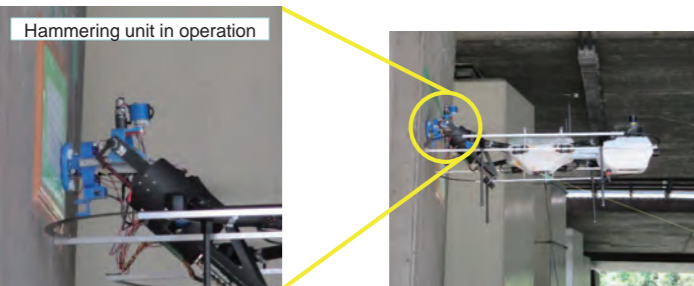
Current Accomplishments (1/2)

Current Status :

· Prototyped flying robot for inspection and proved its operational concept in real environments, such as highways

· Realized fully autonomous flight control under a GPS-denied environment with localization, utilizing Total station and LRF

· Achieved stable hammering where a human inspector can differentiate between clear and non-clear hammering sounds

· Conducted wind tunnel testing at a JAXA facility to verify its flight stability under normal winds of 8 m/s.

· Developed easily deployable safety net system

*LRF : Laser Range Finder

Prototype of flying robot

Wind tunnel testing at JAXA facility

Prototype of safety net system

Flight robot keeping hammering test equipment at the bridge surface


Hammering unit in operation
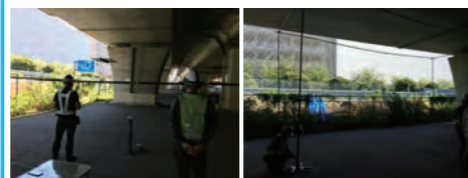
Current Accomplishments (2/2)

Current Status:

· Prototyped hand carriable hammering test equipment for inspection at areas under 6 m

· Proved its performance effectiveness in lowering the inspection cost and time

· Implemented machine learning into the detection algorithm to improve its performance.

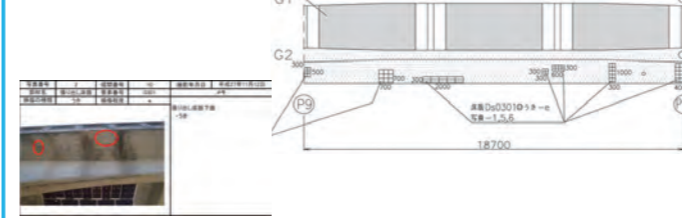· Developed acoustic filter to reduce noise from the flying robot

Prototyped handy inspection unit

Sensor head · Record GUI · Inspector · Co-Inspector
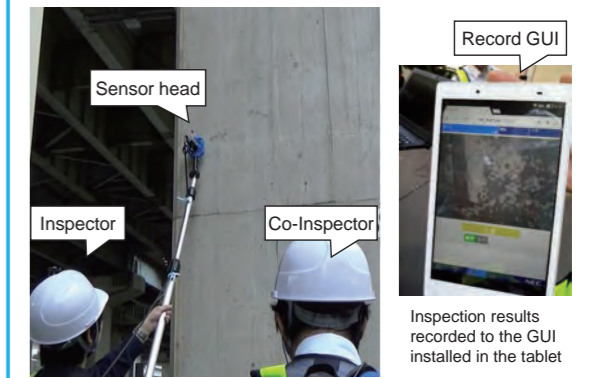
Inspection results recorded to the GUI installed in the tablet

Example of the inspection record generated by the system

Record of spots detected to have defects at Sakiku-bridge in Ibaraki Pref.

Result of concrete defect detection in the test piece

High Accuracy
Average score of the determined damage
Low Accuracy
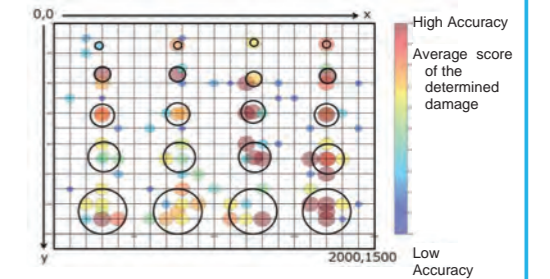
Black area : flacked spot
It was proved that the system can detect those spots with high accuracy

Goals

Final Goals:

<In Common>
· Conduct tunnel/bridge hammering inspection
· Detect flackings in the concrete

<Flying robot with inspection unit>
· Continuous operation for 2 hours
· Operation at 30 m height (max.) and 8 m/s wind (avg.) environment

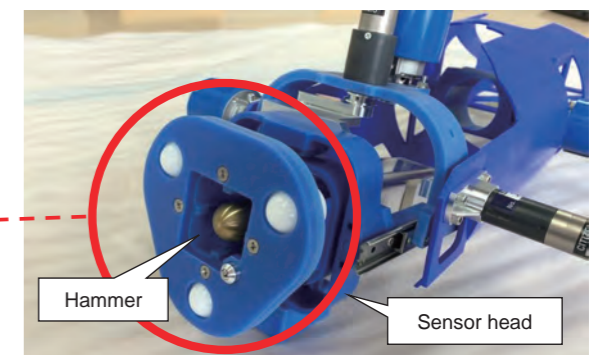<Handy inspection unit>
· Easy inspection under 6 m high area

Social Implementation Steps:

· Replace aerial work platforms with this system

· Lease the system to inspection companies

· Provide inspection portal service in cloud platform

· Evaluate the system in various environments, such as SIP application project at Gifu Univ., to improve its performance

· Apply its technology to different types of inspection

Flying robot under development

Reduced its weight by 40% compared to the previous flying robot

Hammer · Sensor head