51 R&D of a multicopter-based inspection robotic system with visual observation and hammering test devices

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R&D Objectives and Subjects

Background

Problems in infrastructure inspections

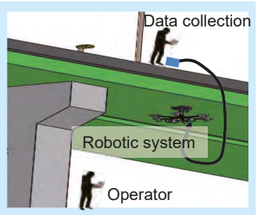
- Costs of the special vehicle
- Safety management
- Dependency on human efforts
- Lack of experts

Special vehicle inspection has limitations

Purpose

Less cost and high efficacy by using drones and automatic data analysis

- Less costs for special materials
- Reduction of road regulations
- High availability of recorded inspection data
- Automatic abnormal detections
- Support for inspection reports

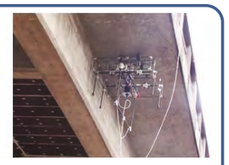


Schematic illustration of the inspection process

Key points

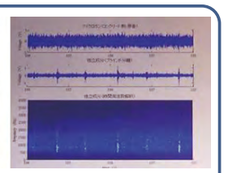
- **Mobility mechanism** with drones and wheels
- **Inspection** by visual observation and hammering tests
- Image and sound-based **abnormal detections**

Flying close to the target



Running on the target

Hammering test

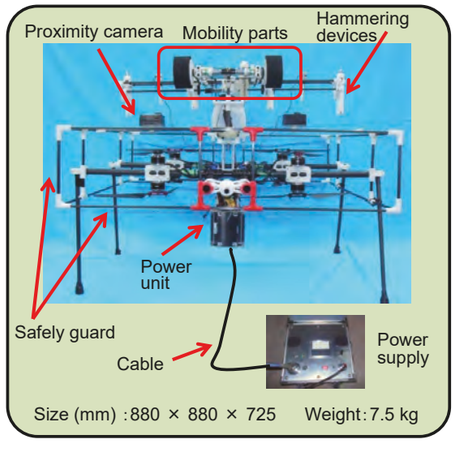


Sound analysis

Current Accomplishments (1/2)

Inspection Robotic System

A multicopter with an inspection system running via independent wheels was developed to realize nonstop running inspections



Size (mm) : 880 × 880 × 725 Weight : 7.5 kg

Flying Mechanism

Small sized system can attach to the target directly
⇒ Small but high performance

(Dual Reversal Quadrotor)

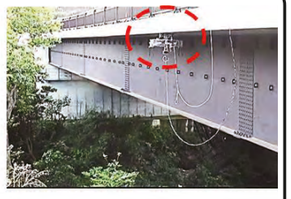
Mobility Mechanism

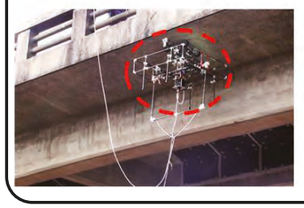
Adaptive for cants of the target
⇒ Flexible wheels

(Pitch : ±15°)

(Roll : ±20°)

Field Inspection





Alternative inspection methods using robotics

- Contact danger areas easily
- Consecutive inspection as getting into touch with infrastructures

Current Accomplishments (2/2)

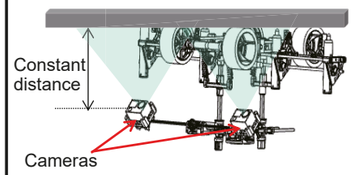
Automatic Inspections

Dual inspection systems with cameras and hammers enable the drone to detect cracks and internal defects

- Prevention of oversight by automatic recording
- Visualization of data

Visual Observation

Close distance video recording



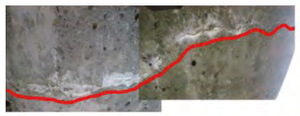
Multi-camera detection

Image Corrections

- Fish eye regulation
- Focal correction
- Image conjugation
- Inspection map generation

Image Inspection

- Automatic crack detection (0.2 mm width)
- Measurements (width, length and position)

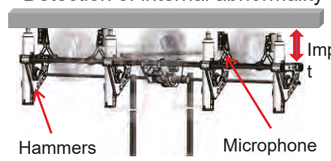


(Free lime)

(Cracks)

Hammering Tests

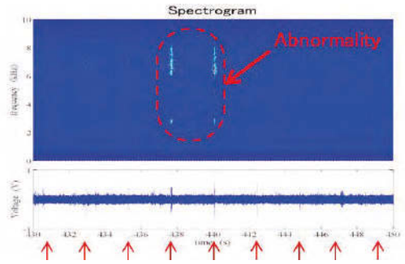
Detection of internal abnormality



Four piston alternative hammers
- Nonstop hammering tests
- Sound recording with microphones

Sound Analysis

- Propeller-induced noise reduction
- Frequency analysis (hole detection at a depth of 60 mm)



Sound Analysis (↑: Impact points)

Goals

Goals at the Final Stage

Functions	Characteristics at the end
Robotic System	Flying area : 30 m radius Cable length : 40 m
Image Inspection	Crack detection : 0.1 mm Position accuracy : ±10 cm
Hammering Test	Internal test : 60 mm depth RC crack : covering depth 30 mm
Depth Measure (Steel Bridge)	Ultrasonic thickness measurement Accuracy : ±0.2 mm
Operation Requirements	Operators : 3 person/robot Wind speed : less than 6 m/s (ave.) Inspection speed : 250 m²/hour

Selling/Rental

- Inspection robotic system
- Functional units (robotic system & inspection)
- Software (image & sound analysis)
- Operators*1 and inspection experts*1
- Training course for operators

(*1 : Only in rental)

Ideal Social Contributions

- Service of inspections
- Selling of the robotic system
- Rental business of the system

Inspection Service

○ Concrete Bridges (RC&PC structure)

Visual Observation (cracks, abrasions)
Target : floor slabs, beams, shoes and so on

Hammering test (abrasions, internal crack*2)
Target : floor slab, beam and so on

○ Steel Bridges

Proximity inspection (corrosion, cracks, abnormalities)
Target : floor slabs, beams, shoes and so on

Ultrasonic waves (depth measure, internal crack)
Target : main & sub beam and so on

○ Tunnels (Examination・Partial Inspection)

Proximity inspection (cracks, abrasions, water leakage, corrosion)

Hammering test (abrasions, internal crack*2)
Target : lining part, boxes and so on

(*2 : internal abnormality by steel corrosion)