■**R&D Topics** : **Robotics Technologies**
■**R&D Theme** : **R&D of a multicopter-based inspection robotic system with visual observation and hammering test devices**
■**Principal Investigator** : **Hideki Wada (Shinnippon Nondestructive Inspection Co., Ltd.)**
■**Collaborative Research Groups** : **Nagoya University, Kyushu Institute of Technology, Fukuoka Industrial Technology Center**

R&D Objectives and Subjects

SIP Cross-ministerial Strategic Innovation Promotion Program
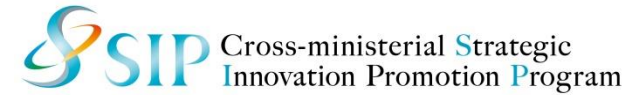
Background

Problems in infrastructure inspections

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

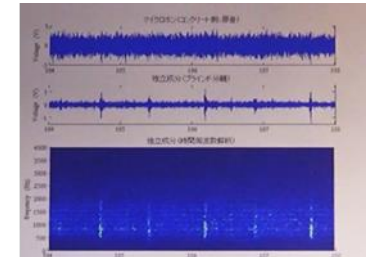Special vehicle inspection has limitations

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
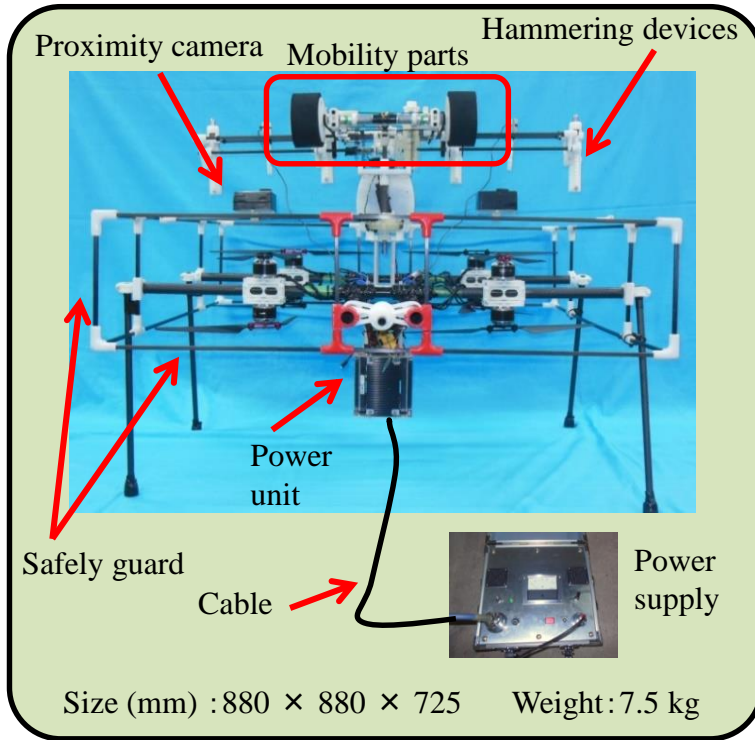➢ Automatic abnormal detections
➢ Support for inspection reports

Data collection
Robotic system
Operator
Schematic illustration of the inspection process
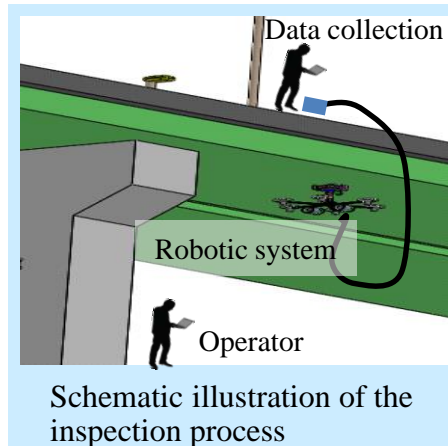
Key points

・ **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

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Current Accomplishments (1/2)

Inspection Robotic System

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

Proximity camera — Mobility parts — Hammering devices

Safely guard — Power unit — Cable — Power supply

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

Alternative inspection methods using robotics
・Contact danger areas easily
・Consecutive inspection as getting into touch with infrastructures
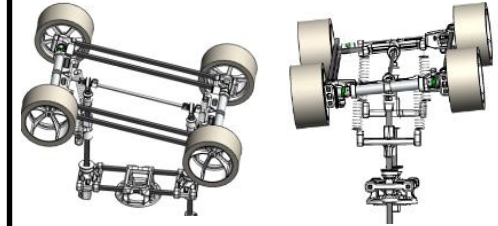
Flying Mechanism

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

(Dual Reversal Quadrotor)

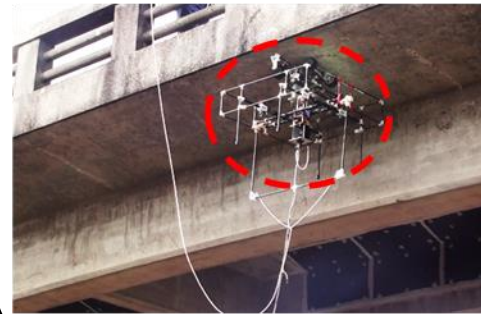### Mobility Mechanism

Adaptive for cants of the target
⇒ Flexible wheels

(Pitch：±15°)   (Roll：±20°)

Field Inspection

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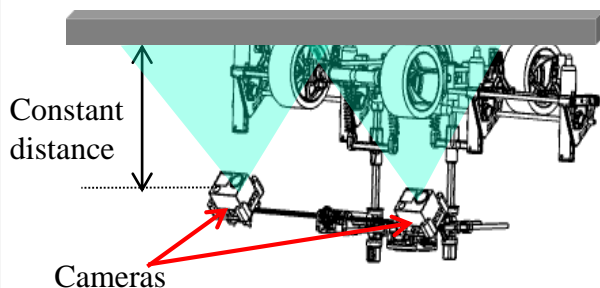SIP Cross-ministerial Strategic Innovation Promotion Program

Automatic Inspections

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

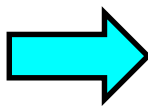・Prevention of oversight by automatic recording
・Visualization of data

Visual Observation

Close distance video recording

Constant distance
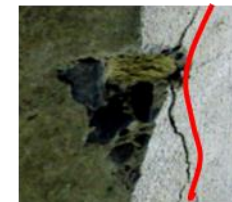
Cameras

Multi-camera detection

Image Corrections

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

Image Inspection
・Automatic crack detection（0.2 mm width）
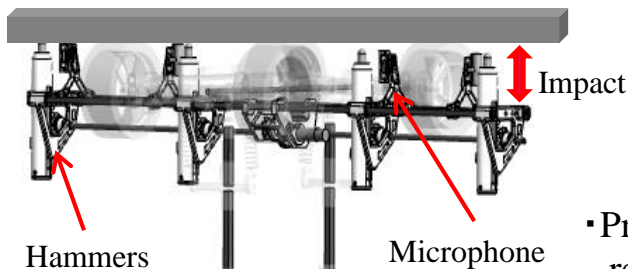・Measurements（width, length and position）

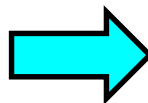（Free lime）　　　（Cracks）

Hammering Tests

Detection of internal abnormality
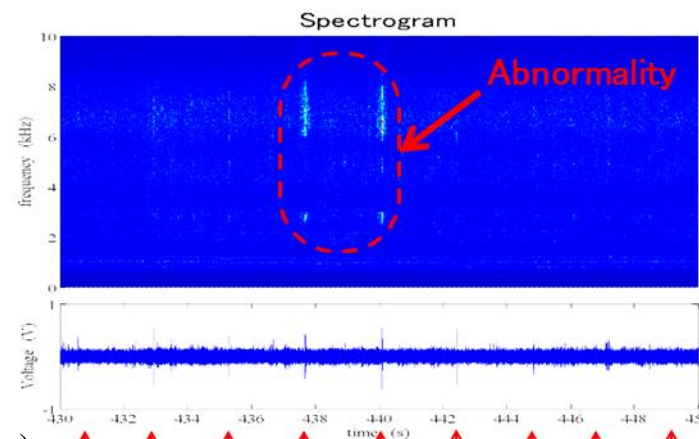
Impact

Hammers　　　Microphone

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)

Spectrogram

Abnormality

Sound Analysis　（↑:Impact points）

Goals

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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）

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