R&D Objectives and Subjects

**Background**
Problems in infrastructure inspections

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

**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

**Key points**

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

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**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

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Background image of a bridge and drone inspection.

Key points image showing mobility mechanism, inspection process, and data collection.

Schematic illustration of the inspection process.

Infrastructure Maintenance, Renovation, and Management.
Current Accomplishments (1/2)

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

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

Mobility Mechanism
Adaptive for cants of the target
⇒ Flexible wheels

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.

**Visual Observation**
- Close distance video recording
- Constant distance
- Multi-camera detection
- Cameras

**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)

**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)

- Prevention of oversight by automatic recording
- Visualization of data

- Spectrogram
- Abnormality
- Impact points

Infrastructure Maintenance, Renovation, and Management
Goals

Goals at the Final Stage

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

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

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)

(*2: internal abnormality by steel corrosion)