

# 50 Development of Unmanned Aerial Vehicles for Observing and Hammering Aged Bridges at Short Range



Principal Investigator Kazunori Ohno (Assistant Professor, Tohoku University)

Collaborative Research Groups RICOH Co., Ltd., Chiyoda Engineering Consultants Co., Ltd., Japan AeroSpace Technology Foundation, Tokyu Construction Co., Ltd.

## R&D Objectives and Subjects

### Objectives

R&D of UAV (Unmanned aerial vehicle) for observing and hammering aged bridges

- Inspect bridges which may not be accessible by a bridge inspection vehicle in a similar time as the conventional system takes
- Minimize cost and time for scaffolding
- Minimize traffic regulation
- Software facilitating formatting inspection reports

### Subjects

- Inspection UAV with a spherical shell that can safely collide with a bridge and reach inner structures of the bridge
- Communication relaying UAV that can attach to a bridge and connect the inspection UAV and the operator
- AI (artificial intelligence) that supports detecting the position and level of damage in inspection images
- Performance demonstrations conducted by specialists of inspection, aerospace, and construction



Final R&D outcomes

## Current Accomplishments (1/2)

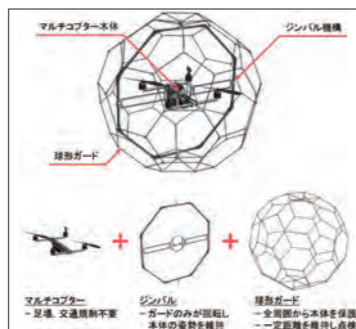
### Inspection UAV with spherical shell (Tohoku University)

UAV protected by a spherical shell which does not crush in a collision

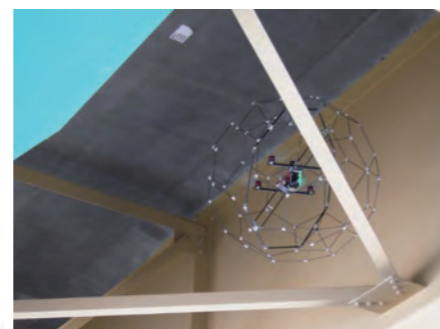
#### Evaluation by MLIT (2016)\*

"Does not require scaffolding unlike conventional methods"

"Can take photos of 0.2 mm width damages (e.g. cracks) with onboard full HD cameras"



Structure of shelled UAV



UAV inspecting inner bridge structure (Diameter: 0.95 m, weight: 2.5 kg)

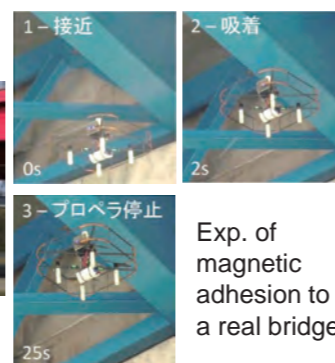
### Communication relaying adhesion UAV (Tohoku University)

UAV capable of attaching to a bridge and relaying communication

- Magnetically attaches itself and relays communication to the inspection UAV with minimum power consumption
- Keeps the operator and the inspection UAV connected to avoid accidents that may be caused by communication loss



Operation of comm. relay



Exp. of magnetic adhesion to a real bridge

\* <http://www.mlit.go.jp/common/001125338.pdf> (in Japanese)

## Current Accomplishments (2/2)

### Detection of damage in inspection images (Tohoku University, RICOH)

Reconstruct a panorama of bridge and detect damages from a close-up video

- Automatic reconstruction of a panoramic image by image processing
- Support making an inspection report by locating damage in respect to the panoramic image
- Support measuring cracks in software



Reconstructed panoramic image of a real bridge



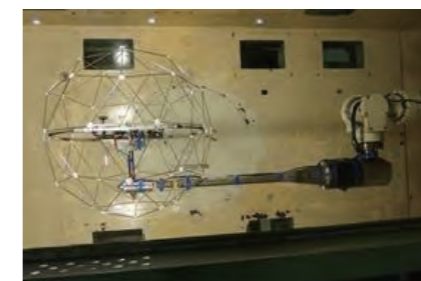
Semi-automatic detection of a crack on a concrete slab

### Performance demonstrations (Chiyoda E.C., JAST, Tokyu Construction)

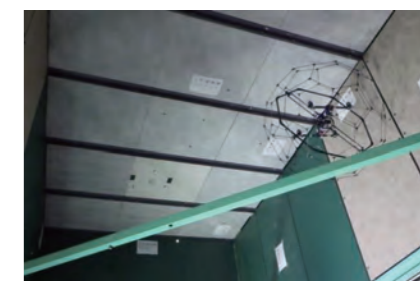
Toward robot technology that works in the real fields, performance demos have been periodically conducted by specialists



Inspection demo at a real bridge (Chiyoda E. C.)



Aerodynamic evaluation in a wind tunnel (JAST)



Repeatable evaluation using artificial weather (Tokyu Construction)

## Goals

### [ Final goals ]

Dev. item	Final goal
Close visual and hammering inspection of bridges by UAVs	<ul style="list-style-type: none"> <li>Target: concrete and metal bridges</li> <li>All devices carried by a car</li> <li>Preparation less than 15 mins</li> <li>Multiple lightweight cameras (&lt; 300 g) for wide angle</li> <li>Continuous flights (10 mins/flight)</li> <li>30-40 mins flight in total for each span</li> <li>Hammering device to detect damage</li> </ul>
Detection of damages using panoramic images and report generation	<ul style="list-style-type: none"> <li>Panoramic image reconstruction from inspection video (few to tens of hours/span)</li> <li>Semi-automatic position/level detection of cracks and corrosion</li> <li>Report generation by pipeline of above tools</li> </ul>

### [ Social implementation plans ]

- By member or licensed companies
- Manufacturing/sales/rental/maintenance of UAVs and/or image analysis and reporting software
  - Education and qualification of operators and instructors

### [ Bridge inspection solution ]

Reduce traffic regulation by using UAVs, and simplify the making of reports by image processing and autonomous functions

