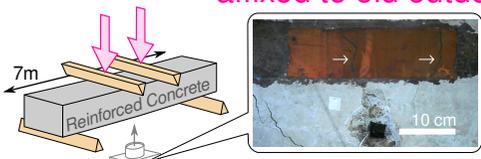


IoT-powered remote sensing system & portable tools for real-time evaluation of **strain imaging sheets** affixed to old outdoor structures



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H. Fudouzi,
& K. Tsuchiya

Acknowledgements to Dr. Yamaguchi & Dr. Matsuda (Nagasaki U)

NIMS
SIP 戦略的イノベーション創造プログラム
Cross-ministerial Strategic Innovation Promotion Program
科研費
KAKENHI

Slide 1

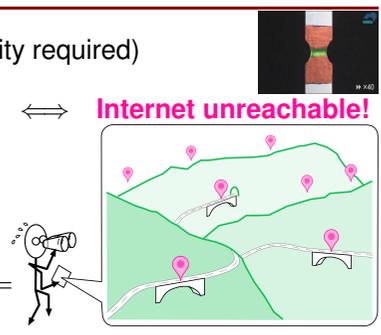
Strain imaging sheets

Pros & Cons

- **Passive** (No electricity required)
- **Clearly visible**
- **2D mapping**

Internet unreachable!

Use micro-computers!



Slide 3

Strain imaging sheets

A potential target

- Civil engineering
 - ⇒ Many old outdoor structures
 - ⇒ Need to detect potential risks



Genoa bridge collapse in Aug. 2018

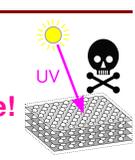
https://en.wikipedia.org/wiki/Ponte_Morandi

Slide 2

Notice

Related talk

- **Passive** (No electricity required)
- **Clearly visible** ⇔ **UV-degradable!**



Tomorrow, 4:30 PM @ Crestone Salon B

“**Weatherability improvement** of strain imaging sheet to use in real field for infrastructure inspection tech.”

H. Fudouzi *et al.* (10970-44)

Slide 4

OVERVIEW Enhance the value of strain imaging sheets

Strategies

How do we realize efficient data acquisition?

Remote sensing

How do we connect our sensor to the Internet?

Smart inspection

How do we make non-experts' evaluation reliable?



Slide 5

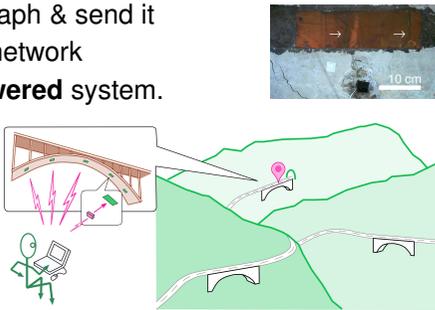
Strategy 1 Compare w/ IoT Trail Camera

	this work		
Camera view			
Solar irradiation	Limited	Maximized	
Lighting situation	Dim - Dark	Normal	

Slide 7

Strategy 1 Make them "connected" w/ IoT tech.

- Take a photograph & send it over a mobile network on a **solar-powered** system.




Slide 6

Strategy 2 Use manpower

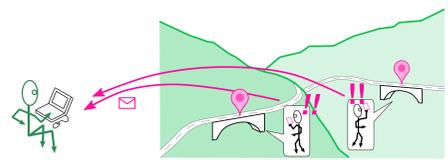
- Ask **local volunteers** to evaluate/monitor them
 - ↑ non-experts
- Must provide **easy-to-follow instructions**



Slide 8

Strategy 2 **Use manpower**

- Ask **local volunteers** to evaluate/monitor them
- Must provide **easy-to-follow instructions** w/ **a special application on their PDAs**



Slide 9

Remote sensing **Exposure test site**



4 P.M.

Slide 11

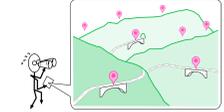
OVERVIEW Enhance the value of strain imaging sheets

Strategies
Make use of micro-computers, IoT tech. & PDAs.

Remote sensing

How do we connect our sensor to the Internet?

Smart inspection
How do we make non-experts' evaluation reliable?



Slide 10

Remote sensing **Strain imaging sheets installed**



⇒ Automated monitoring stations

Slide 12

Remote sensing Automated monitoring station



- **Must save electricity**
- Take a photo hourly
- Camera & network: connected only when needed



Micro-computer w/ switching circuit

⇒ Power consumption: 0.1 W @ idle

Slide 13

Remote sensing Wireless data acquisition




3G mobile network



Strain visualization stickers installed on the bridges in NIMS
West South East
Monitoring screen



Micro-computer w/ switching circuit

⇒ Stable operation for 1 year+

Slide 15

Remote sensing Semi-night vision camera (color)




Normal

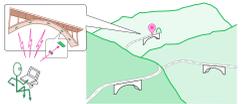





⇒ No extra illumination needed in the shade

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OVERVIEW Enhance the value of strain imaging sheets



Strategies

Make use of micro-computers, IoT tech. & PDAs.

Remote sensing

Developed solar- & IoT-powered observatory stations

Smart inspection

How do we make non-experts' evaluation reliable?

Slide 16

Smart inspection Provide them a portable tool

- to extract strain-free area w/ real-time image analysis on their PDAs
- “Bring Your Own Device” (BYOD) like

Slide 17

Smart inspection Make the gradation clearer

Slide 19

Smart inspection Color extraction

RGB x Mask =

HSV-histogram

Histogram back-projection (Swain & Ballard, 1990)

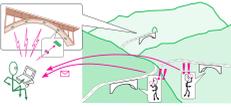
Slide 18

Smart inspection Available in various PDAs

Bring Your Own Device	UI & camera control	Image processing
Android	Java (OpenCV)	C++ (OpenCV)
iOS	Swift	
Windows 10	C#	
+ USB Camera	C++ (OpenCV)	

Slide 20

SUMMARY Enhance the value of strain imaging sheets



Strategies
Make use of micro-computers, IoT tech. & PDAs.

Remote sensing
Developed solar- & IoT-powered observatory stations

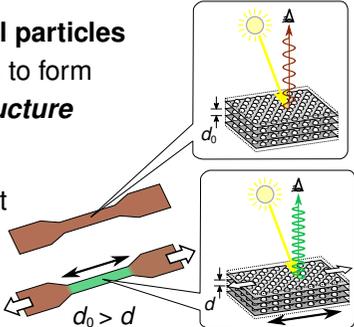
Smart inspection
Provide a portable evaluation tool into their PDAs.

SIP 戦略的イノベーション創造プログラム Cross-ministerial Strategic Innovation Promotion Program 科研費 KAKENHI NIMS

Slide 21

Introduction Strain imaging sheets

- Polystyrene colloidal particles on PET film, arranged to form **photonic crystal structure** (Fudouzi 2009)
- Color** of reflected light varies w/ **strain** along the surface.



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