Visual verification of civil engineering structures by UAV

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KEY WORDS: UAV, Near Infrared Imagery, Photogrammetry, Civil Engineering Structure

ABSTRACT:

It has passed over 50 years since more than half of civil engineering structures in Japan were constructed. Because almost structure were constructed between the high-growth era after World War II in Japan. If their structures are not maintained, it is difficult that they use safely. Actually, the accident that the ceiling board of tunnel was fall and crashed was occurred. Therefore, it is necessary to maintain and to pre-inspect the structure to prevent an accident. Initial check is usually performed by viewing and sounding using a hammer by a skilled engineer. However, since a skilled engineer and a budget for initial check are insufficient, we are anxious about check fully not being performed. As it being shown, serious accidents have occurred, such as tunnel collapse. Therefore, it is expected to develop the method of initial check for civil engineering structures from simple and low cost.

In this study, we have developed and verified the method of initial check for civil engineering structures by using the UAV. A digital camera and IR digital camera were loaded on the UAV. The IR digital camera was modified to remove an infrared cut filter and to put on an infrared pass filter from an ordinary digital camera. Visual verification was performed in places where viewing is usually difficult, such as the floor slab of a bridge, using the developed system.

As the results, the omission of the bolt, exfoliation of the concrete surface, etc., were detected. But the verifications were difficult at the dark place by a shadow. It turned out that the devices of lighting on visible and IR is required. UAV turned out, essential to visual verification of civil engineering structures.

1. Introduction

1.1 Background

It has passed over 50 years since more than half of civil engineering structures in Japan were constructed. Because almost structure were constructed between the high-growth era after World War II in Japan. If their structures are not maintained, it is difficult that they use safely. Actually, the accident were occurred, such as the ceiling board of tunnel was fall and crashed, and a bridge was collapsed by deterioration of a steel body. Therefore, it is necessary to maintain and to pre-inspect the structure to prevent an accident. In this year, Japanese government defined the statute that the civil engineering structure must be pre-inspected every five years. Local government takes charge of pre-inspection. However, the local government hasn't adequate budget to check out the structure and technology to pre-inspection. So, it is required that the technology to pre-inspect cheap and easy is developed. Especially, the pre-inspection for the base structure of bridge spend a lot of cost because the scaffold has to construct for pre-inspection closely.

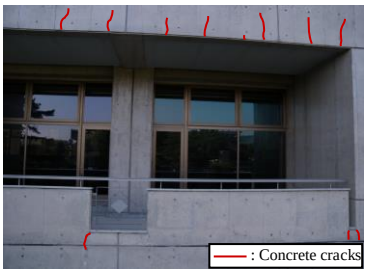
1.2 Purpose of research

It is necessary to carry out inspection work in order to achieve a healthy degree of bridges. There are two types of visual inspection and non-destructive testing to bridges inspection. Visual inspection is one that is confirmed visually and damage to the concrete surface. Non Destructive testing is to investigate the degree of damage to the concrete inside using the test equipment. Non-destructive testing is information sources needed to estimate the health of the Bridge. However, this testing is not a sustainable inspection technique for cost and time-consuming. Therefore, sustainable burden less new inspection methods are required. Accordingly, Inspection technique of the new visual inspection has been attention. In this study, we aim to span extension of the non-destructive testing by performing a visual inspection at the UAV. This test uses the captured image of a camera loaded on the UAV.

2. Experiments

2.1 Feature of UAV

In this experiment, we investigate platform for Visual verification of civil engineering structures. In recent years, satellite remote sensing is innovated, we can obtain high resolution imagery. Though, it is not possible to observe the ground structures. Recently, the small UAV or UAS (Unmanned Aerial System) in other words are coming in remote. It is possible to perform observation of satellite observation is difficult location for the UAV is small.



DJI Fantom2	
Type	Quad Copter
Size	400mm × 400mm × 190mm
Weight	1030g
Time of flight	25mins
Payload	270g

Figure1. Landscape of the UAV flight and Photographed image

2.2 Introduction of the sensor

In this study, it is checked whether possible to detect cracks in the concrete from the camera that was loaded on the UAV. We were selected the camera suitable for that. Is shown below the camera of three types were selected.

Nikon COOLPIX P6000	
Number of pixels	13.5 MP
Sensor size	7.6 × 5.7
Weight	240 g
Shooting procedure	Time Lapse

GoproHERO3(Black Edition)	
Number of pixels	12 MP
Sensor size	5.9mm × 4.4mm
Weight	170 g
Shooting procedure	Time Lapse/Wi-fi Direct

RICOH THETA	
Number of pixels	Unknown
Sensor size	Unknown
Weight	100 g
Shooting procedure	Wi-fi Direct

Figure2. Specifications of the using cameras

2.3 Near-infrared camera

In this study, it is checked whether possible to detect cracks in the concrete from the camera that was loaded on the UAV. Utilizing the N-IR camera to detect the concrete cracks. We made N-IR camera by processing the camera by NIKON. Internal filter that can visualize the visible light is visceral to general Digital camera. It is necessary to replace N-IR filter to internal filter in order to shoot an infrared photograph. We were using an optical filter of the product of Fuji Photo Film Co., Ltd. for three types in this experiment. We have shown in Fig.3 is the reflection characteristic of used optical filter (SC-70, SC-72, IR-76).

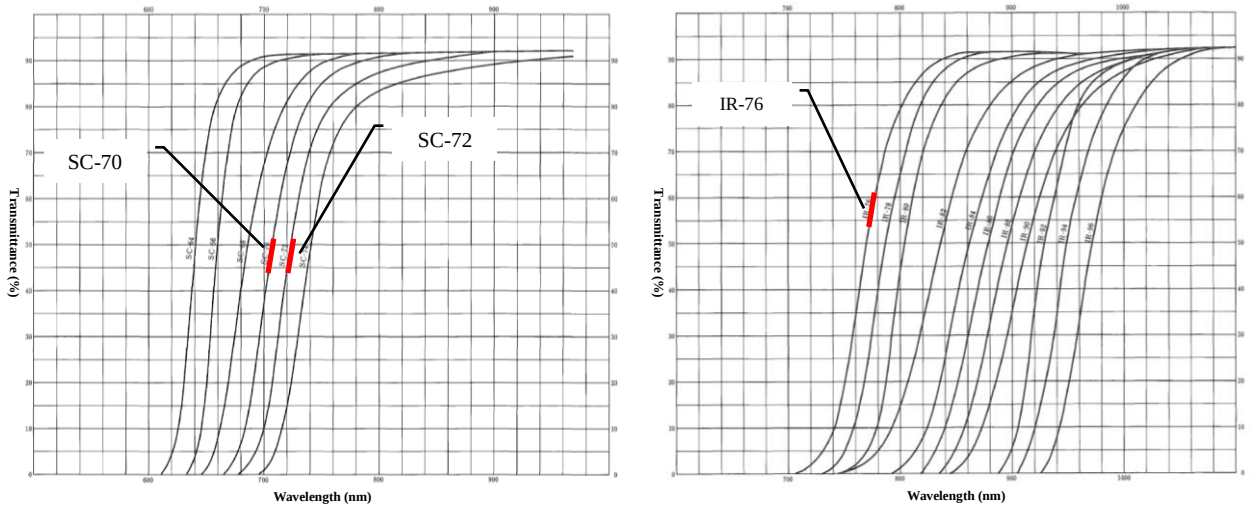


Figure3. Characteristics of the product of Fuji Film Co., Ltd. optical filter3. Result & Conclusion

3. Result & Conclusion

3.1 Visible of the bridge

We experiment was conducted to target the PC girder bridge in the vicinity of Kanazawa Institute of Technology. This time, it was confirmed visual effect using a Nikon camera. However, we did not fly the UAV because the wind was strong. So, we were taken by the state away 2m from the subject. It was possible to check the state of the bolt and a concrete surface from the captured image. It is possible that the holes for the bolts to confirm the steel member center if you look at the fig.4. Also, we were confirmed peeling to the concrete surface. In this result, it can be said that it is possible to inspect the bridge from the camera image in a state in close.

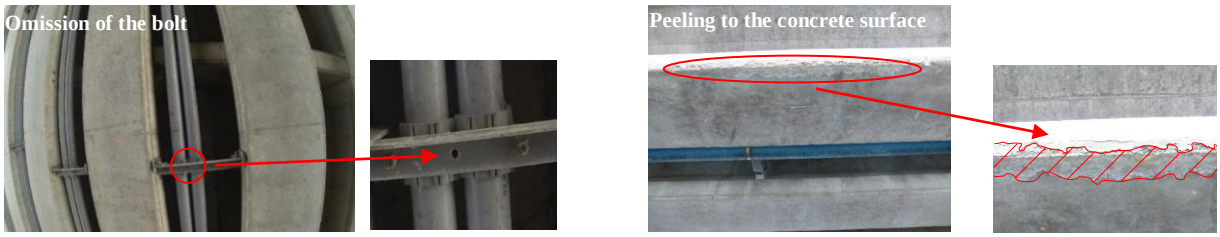


Figure4. Visible of the bridge

3.2 Concrete cracks

We conducted our experiments using an N-IR camera in order to perform detection of concrete cracking. We conducted our experiment by preparing two-body non-muscle cylinder specimen is cracked. We have required concrete containing the crack in the experiment. So, I was prepared two-body non-rebar concreate specimen containing the crack. We were shown in Fig.5 the captured image. We compared both images by differential analysis.

Primary colors Imagery | SC-70 colors Imagery | SC-72 colors Imagery | IR-76 colors Imagery

Figure5. Black-and-white image of concrete cracks

It was possible to obtain such a result from an acquired image. Fig.6 is the result of the differential analysis of the SC-72 and the normal image. We can know the change point of the image difference analysis. It could be displayed by emphasizing the cracks of about 0.05mm or more from the image. Therefore, There is a possibility of detect cracks at risk by the observation the wavelength range of the cracks.

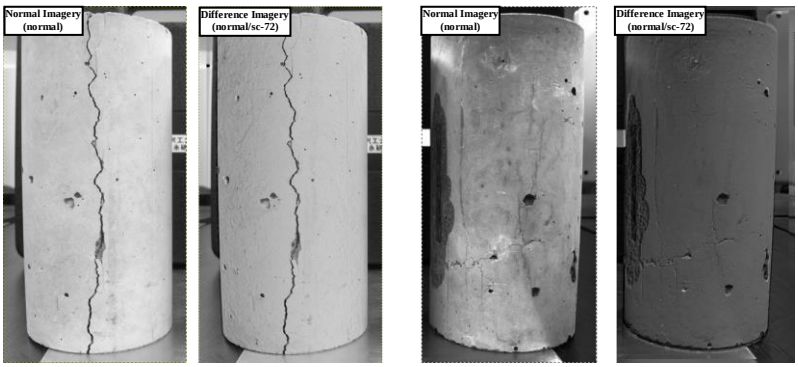


Figure6. Difference image using the near infrared image and the normal image

4. Future view

We did experiments on bridge visual inspection in this study. We were able to re-confirm the significance of the application of the UAV to the bridge inspection. In the future, we will continue to validate the serviceable range of UAV inspection and GPS reception strength at the bridge near. It was also found the possibility of displaying with an emphasis upon certain crack by exploring the wavelength range corresponding to the crack width for concrete cracking. In the future, we hopes to investigate the wavelength range corresponding to the crack width.

5. Acknowledgment

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