Development of 2IN1 Hybrid Measuring Device Using EO/IR Camera

Ju-Yeong Jung*, Hyuk-Jin Yoon†, and Dae-Hyun Kim*

Abstract

Hybrid measuring device using EO/IR camera was developed in this paper. 2IN1 module type design to acquire EO and IR image simultaneously was used and also was designed to acquire EO/IR image, distance and location information at a time by integrating Lidar and GPS module. For outdoor photographing, passive thermal image technique without using additional artificial heating system was adopted, and for convenient use of measurement data, a module to connect UAV and measuring device, measuring device and PC, respectively, was used. External power supply was used for image acquisition module with 12V input, maximum 7A, complete size 500 x 500mm and 6kg in weight. Further test of the device will be conducted to connect with the software designed to detect concrete structure surface defect and damage, thereby applying to field instrumentation.

Keywords: Railway Maintenance, UAV (Unmanned Aerial Vehicle), EO camera (Electric-Optical camera), IR camera (Infrared camera)

1. Introduction

As railway system and infrastructure have been deteriorated in line with their service life being expired, potential accident risk and maintenance cost are on the rise rapidly and thus advancement of maintenance technology becomes more than critical. Maintenance is based on data measured at the site and for measuring the data more efficiently, advanced technology integrating with ICT is need. In this regard, it’s necessary to urgently develop hybrid measuring and monitoring system for which demand is on the rise and the study to apply it to UAV (Unmanned Aerial Vehicle) is underway now[1]. In this paper, 2IN1 hybrid measuring device using optical-thermal image camera was developed in a bid to prevent in advance the accident with railway system and infrastructure as well as enhance the utilization of measured data. The method to interlock with UAV to increase the use of 2IN1 hybrid measuring device was developed and tested at the site.

2. Development of EO/IR hybrid measuring device

Electric-Optical camera and Infrared camera were used for hybrid measuring device which detects concrete structure surface defect and damage. Furthermore, Lidar and GPS module were integrated to improve the accuracy of the outcome and the equipment to acquire EO/IR image, distance and location information was provided. Additionally, measuring device was designed to interlock with UAV so as to enhance the utilization of the product to be developed.

2.1 Details and module configuration of the product

For acquiring EO/IR image at a time, Lidar module was added to 2IN1 module equipment to acquire data on distance to the object. Using distance data from Lidar module, EO image-acquiring equipment was designed to have AutoFocus function. That is, it’s designed to synchronize EO/IR image, data on distance to the object and GPS information to save it in a single file. Finally, module to connect UAV-device and device-PC, respectively, was provided for convenient use of measured data.

Block diagram of image acquisition module when connected with UAV is as follows. Image acquisition module has
EO camera, IR camera and Laser Rangefinder inside together with camera processor and Gimbal controller to control them. When mounted on UAV, camera control line and Gimbal control line are connected to FC (Flight Controller). To extract the data after landing, Ethernet line is connected to user’s PC.

When connected to PC, module configuration is as shown in Fig. 1 below. Image acquisition module is connected to Payload Manager S/W in PC and this software functions to control and test in user’s PC.

External power supply was used for image acquisition module with 12V input, maximum 7A. This image acquisition module was assembled in payload and complete size is 500 x 500 mm and weight 6kg.

3. Selection of photographing technique with thermal image camera

3.1 Principle of thermal image camera

Thermal image camera was developed based on principle that all objects exceeding absolute temperature radiate infrared from the surface and infrared energy radiated is heavily dependent on temperature of the object. So, when photographing infrared energy radiated from the surface of the object by infrared camera, thermal image depending on temperature distribution of the object could be obtained. As infrared thermal camera image camera displays

<table>
<thead>
<tr>
<th>Table 1 Image-acquiring module configuration</th>
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<tbody>
<tr>
<td>Equipment</td>
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<tr>
<td>Quantity</td>
</tr>
<tr>
<td>EO, IR image acquisition equipment</td>
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<tr>
<td>Real-time image acquisition equipment (for UAV)</td>
</tr>
<tr>
<td>Range finder (Lidar)</td>
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<tr>
<td>Control, power device</td>
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<tr>
<td>Payload equipment set</td>
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<tr>
<td>Gimbal (for UAV)</td>
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</table>

Fig. 1 Module configuration when connected to UAV

Fig. 2 Module diagram when connected to PC

Fig. 3 Payload manager S/W

Fig. 4 EO/IR image acquisition equipment


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- reflected energy from surrounding area and infrared energy in the atmosphere, besides infrared energy radiated from the object, the image on display is qualitative image resulting from temperature difference and thus temperature distribution characteristics may be different by various factors. Included in variables which have effect on infrared thermal image are surrounding environment (temperature, humidity, wind velocity and so on), performance of infrared camera, and surface condition of the object and measurement location as well as the measuring skill of the measurer. And infrared thermal image camera is the non-destructive measuring device using non-contact temperature measurement, which is thus harmless to human body and furthermore, it displays the temperature distribution of the object in image which allows easy 2 dimensional monitoring and analyzes the result upon photographing which allows real-time diagnosis and in addition, as it detects infrared radiation, not actual temperature, photographing at nighttime is possible.

3.2 Kinds of photographing technique with thermal image camera

Viewing photographing technique with thermal image camera, there are passive thermal image technique which detects by temperature difference in the object or temperature difference between the object and outside the object or by infrared directly radiated from the object without external heating or cooling, and active thermal image technique which photographs the temperature variation over time by heating or cooling the object using external light or heat source and, and pulse infrared thermal image technique which measures temperature variation after instantly heating the object by short thermal simulated pulse, and lock-in technique which detects abnormalities by inserting simulation source to the object with harmonic function and then analyzing response signal such as phase and amplitude of the object. In this test, passive thermal image technique which is cost efficient and requires no other equipment than display of infrared camera, simple measurement process and can photograph the object in operation at safe distance without interrupting the operation was adopted and applied to the field test[2-5].

4. Field test of EO/IR hybrid measuring device

Field test was conducted after connecting image acquisition module to UAV as the aerial photographing.

For safety reason (safety distance and draft), photographing was carried out at 6 m distance and the result is as follows.

In image acquired by EO/IR hybrid measuring device, on top left of IR image or top left of EO image X: 41.56 cm, Y: 27.9 cm, overlay appeared which corresponds to X: 1179 px, Y: 790 px in pixel. Overlay is as the Fig and Table below. Through further study, it’s intended to conduct additional test to acquire image showing crack, strip-
ping or efflorescence so as to detect the concrete structure surface defect or damage and then classify the characteristics of damages to interlock to software that detects the defect or damage automatically, thereby applying it to field instrumentation.

5. Conclusion

In this paper, 2IN1 hybrid measuring device using optical-thermal image camera was developed in a bid to prevent in advance the accident with railway system and infrastructure as well as enhance the utilization of measured data. To develop hybrid measuring device used to detect concrete structure surface defect or damage, EO/IR image, data on distance to the object and GPS information were synchronized and saved as a single file and for convenient use of measured data, module linking UAV-measuring device and measuring device-PC was provided. External power supply was used for image acquisition module with 12 V input and maximum 7 A. Such image acquisition module was assembled in payload frame and the size of completed assembly is 500 x 500 mm, and the weight 6 kg. Passive thermal image technique which is cost efficient and simple and photographs the object in operation at safe distance without interrupting the operation was adopted and applied to field test, and to acquire EO/IR overlay image after field test, it’s adjusted to produce overlay on EO image, top left X:41.56 cm, Y:27.9 cm. Through further study, it’s intended to conduct additional test to interlock with the software for automatically detecting concrete structure surface defect or damage, thereby applying to field instrumentation.

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References


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<th>Table 2 Overlay value</th>
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<tbody>
<tr>
<td>Category</td>
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<tr>
<td>Pixel</td>
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<td>Unit</td>
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Table 2 Overlay value