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Abstract

Effect of using a visible camera in a remote crack detection system using infrared thermography on an actual bridge †

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Abstract

The time change in data measured by infrared thermography is used to analyze thermoelastic stress. Displacement caused by the load on the measurement object is the cause of the apparent temperature change. To prevent this, it is effective to photograph the measurement object with a visible camera synchronized with the infrared thermography. The displacement of the measurement object calculated from the visible image is converted to the movement in the infrared thermography, and the displacement is corrected. In this study, a system was developed using thermoelastic stress analysis (TSA) to measure temperature changes due to the load when a car passes over a steel bridge.

Keywords: crack, remote, thermoelastic, infrared, visible

1. Introduction

As steel bridges age, it is becoming increasingly important to investigate the occurrence and progression of fatigue cracks. Traditionally, magnetic particle inspection has been widely used to inspect steel bridges for cracks, but this requires getting close to the object being inspected. Furthermore, the object is often located at a high altitude, which requires time and money for preparations such as setting up scaffolding and arranging a high-altitude work vehicle, and also requires measures to address the dangers of working at height. Infrared thermography can remotely measure the temperature required for crack detection without contact. If cracks are present in a structure, the stress concentration area at the tip of the crack can be detected by thermoelastic stress analysis.

In this system, the weight and passing volume of normal automobiles are used as the dynamic load applied to the structure. The timing and speed of passing automobiles are random. Because the temperature fluctuations used in thermoelastic stress analysis are small, there is a possibility that the reflected components from heat sources in the surrounding environment may be mistaken for temperature fluctuations caused by the passing of a vehicle. Therefore , a monitoring system was developed that obtains displacement information from high-resolution visible images acquired in synchronization with infrared thermography, detects passing vehicles, identifies the timing of changes caused by the passing of a vehicle, and saves measurement data only when a vehicle passes.

In the monitoring system, the synchronous output signal from the infrared thermography (FLIR A6751) is used as the synchronous input signal for the visible camera (Basler acA1920-150um). The measurement data for each frame from the infrared thermography and visible camera is stored in a ring buffer, and after a certain amount of time has passed since the displacement amount calculated from the visible image data exceeds a threshold, the data stored in the ring buffer is saved in storage, making it possible to save the measurement data before and after the timing when it is subjected to weighting due to vehicles randomly passing by. (Figure 1)

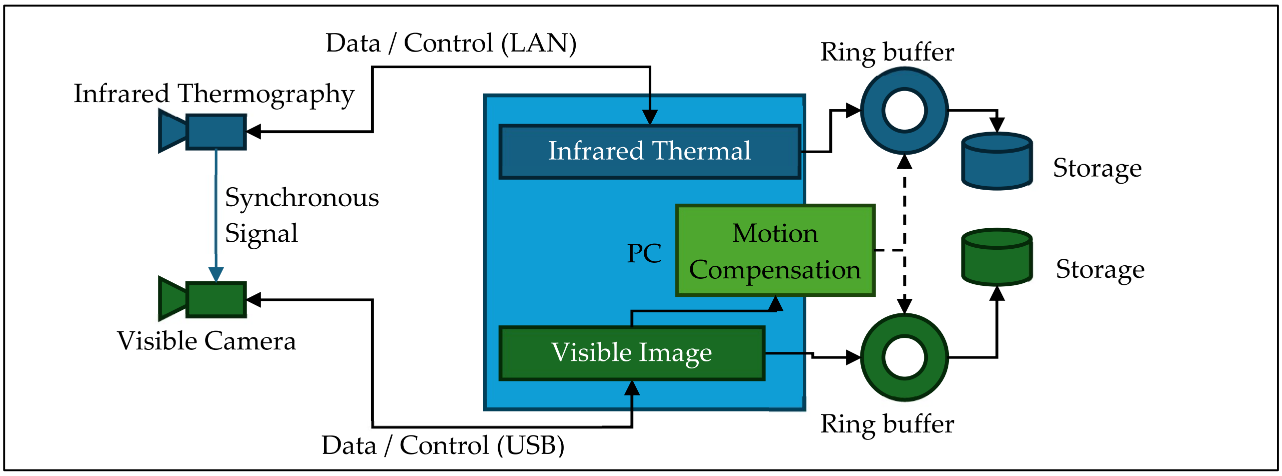

Figure 1. Configuration of the monitoring system

2. Background

The load of a vehicle passing over a bridge causes a deflection of the bridge, which causes an apparent temperature change in the temperature distribution measured by infrared thermography. The amount of deflection of the bridge is calculated from images taken by a visible camera synchronized with the infrared thermography, and the deflection of the bridge on the infrared thermography is converted into a movement on the infrared thermography to correct the deflection of the bridge on the infrared thermography, thereby suppressing the apparent temperature change and improving accuracy. [1]

3. Analysis

The area where the actual bridge was measured (red circle) was approximately 15 m away from the camera, and a lens with a focal length of 200 mm was used.

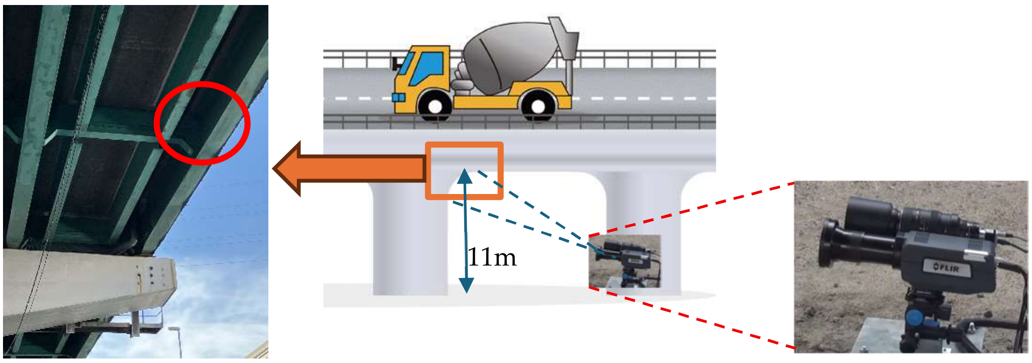

Figure 2. Measurements of an actual bridge

The measured infrared thermography image and visible image are shown in Figure 3.

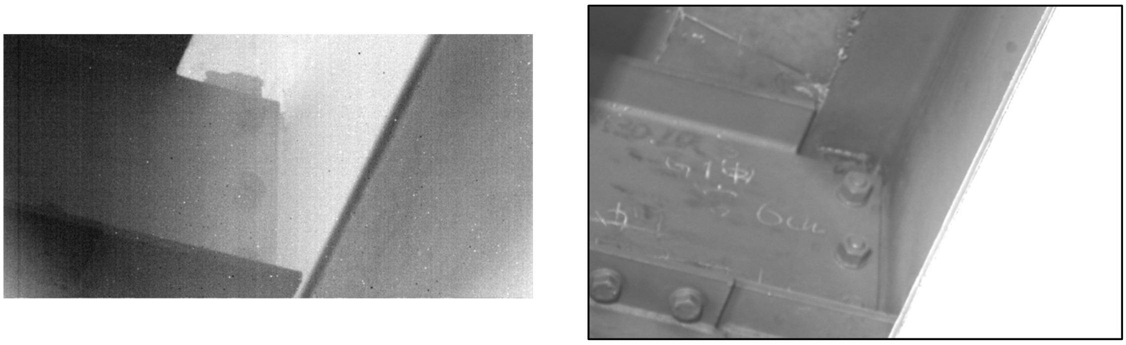

Figure 3. Measurement images (left: thermography, right: visible light camera)

Figure 4 shows the changes in bridge deflection displacement and temperature over time during measurement.

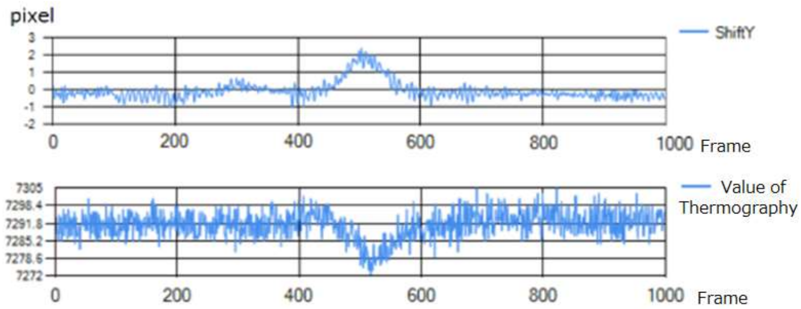

Figure 4. Changes in bridge deflection and temperature over time

The deflection displacement of the bridge was corrected, and the changes in the temperature distribution image were analyzed using autocorrelation lock-in to calculate the stress distribution.

In the gray display, the area where stress is concentrated at the tip of the crack is bright, and in the color display it is displayed in red.(Figure 5)

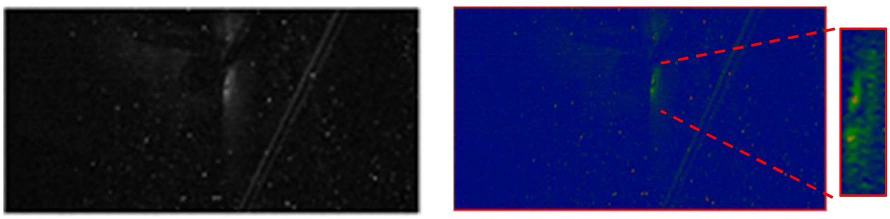

Figure 5. Stress Distribution Diagram

In addition, a homography matrix(H) is calculated from four points in the lyrics image and the infrared image. (Figure 6)

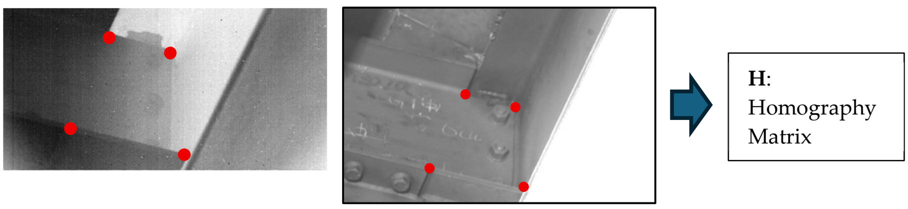

Figure 6. Calculate Homography Matrix(**H**)

by mapping with Matix(**H**) the stress distribution image onto a visible image, it becomes easier to identify the tip of a crack in an actual bridge.(Figure 7)

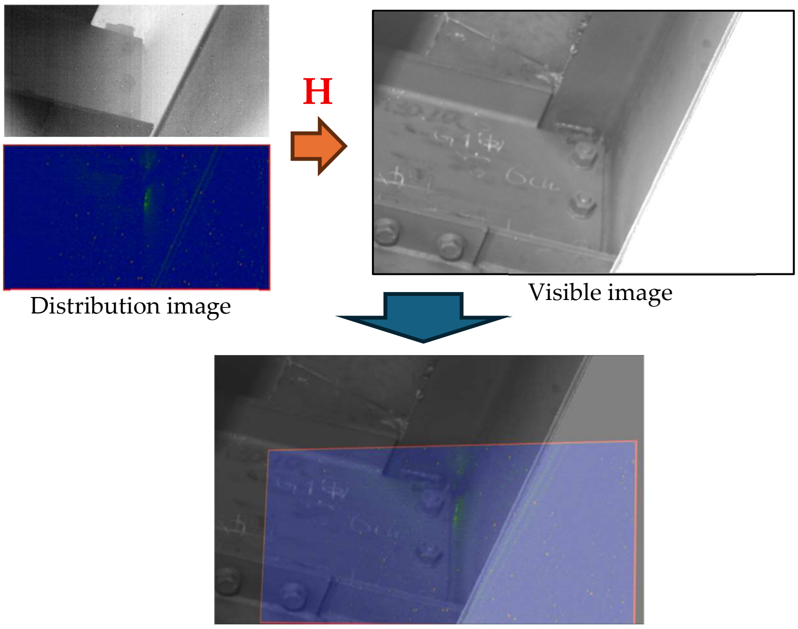

Figure 7. Visible image of stress distribution mapping

4. Conclusion

When this system was applied to an actual steel bridge, it was found that displacement measurement and position correction using a visible image camera were effective in improving measurement efficiency and accuracy in TSA measurements that utilize the load of randomly passing vehicles.

References

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