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Coupon Test of an Elbow Component by Using Vision-based Measurement System

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1. Introduction

The physical properties of materials are critical and contact sensors such as strain gauge are used for material evaluation. However, contact sensors have limitations in the surface condition, temperature, and shape of objects and errors may be generated depending on the location and attachment type of sensor because the values are measured at the point of contact of a structure. Among the various methods to overcome this shortcoming, vision-based methods to measure the strain of a structure are being proposed and many studies are being conducted on them. The vision-based measurement method [1] is a noncontact method for measuring displacement and strain of objects by comparing between images before and after deformation. This method offers such advantages as no limitations in the surface condition, temperature, and shape of objects, the possibility of full filed measurement, and the possibility of measuring the distribution of stress or defects of structures based on the measurement results of displacement and strain in a map.

2. Methods and Results

In this study, a vision-based measurement system was applied to the measurement of strain in the coupon test of materials. This vision-based measurement system consists of a CMOS camera, a lens, and a notebook computer. The strain was measured with this system using 1D average strain, strain between two points, and strain using shape function. Then the results were compared.

2.1 Digital Image Correlation method

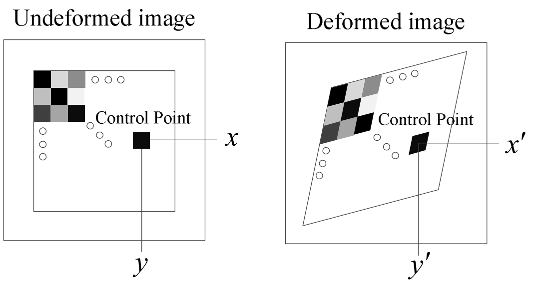

Fig. 1. Pixel coordinates of image before and after deformation

Digital image correlation method [2] is an optical processing method that can evaluate images obtained from the surface of the target object in all areas. Displacement is obtained by tracing the movements from the images of random speckle patterns before and after deformation of the object. Fig. 1 shows the images before and after deformation of the area to be measured. The locations of pixels can be expressed using the normalized cross correlation [3].

2.2 Average strain measurement

The average strain of a structure can be determined by using the vision-based measurement system. When the axial displacement against the reference point along the axis is plotted to the pixels of each image and lines are plotted using the linear function, its slope is the true strain.

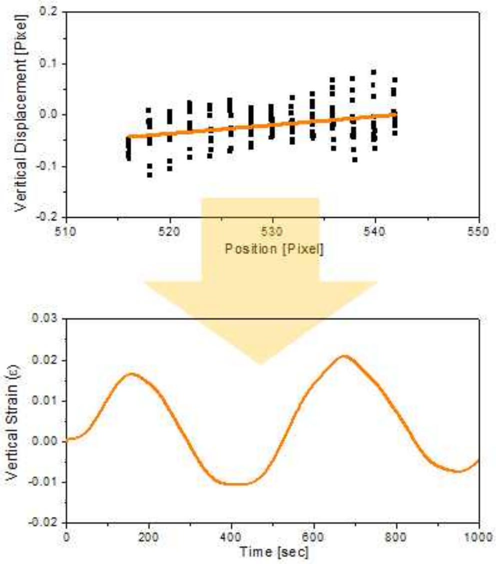

Fig. 2. Average strain

2.3 Strain measurement between two points

The strain of an image is the average of local strains at each point between two reference points in the image. The strain ($\Delta L_x / L_x$, $\Delta L_y / L_y$) can be determined by dividing the initial length of pixels between two reference points by the length of pixels that have been deformed.

2.4 Shape function

A shape function[4] is used to predict displacement in the surrounding area based on the displacement measured at each point. The strain is calculated by interpolating the displacement using the element shape function. The second order shape function is used for measurement. Fig. 3 shows the method of estimating the strain using the second order shape function.

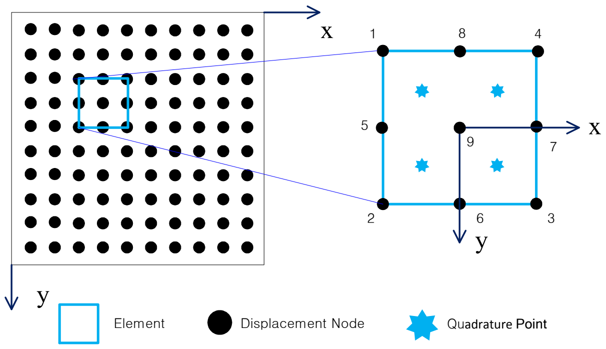

Fig. 3. Second order shape function

2.5 Coupon Test

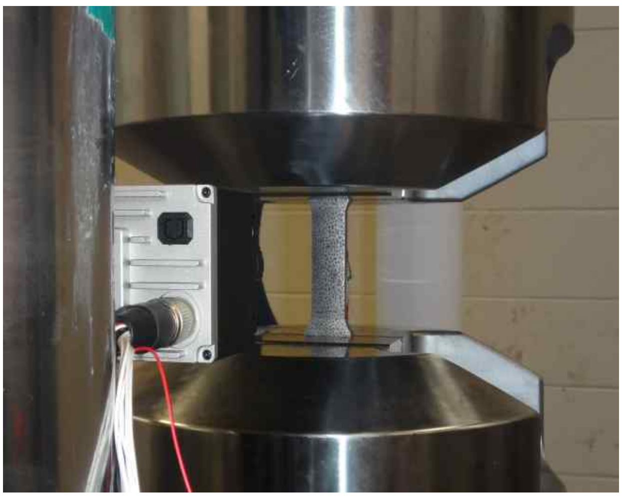

Fig. 4. Specimen and vision-based measurement system

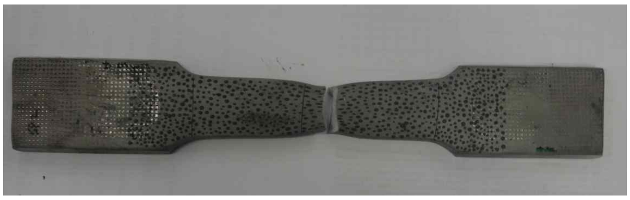

Fig. 5. Fracture shape

To measure the physical properties of materials using images, specimens were gotten from the elbow component and a coupon test was conducted. Fig. 4 shows the specimen and the vision-based measurement system used in the coupon test, and Fig. 5 shows the fracture shape. Fig. 6 shows the average strain, strain between two points, and strain using shape function, all of which were measured at the center of specimens.

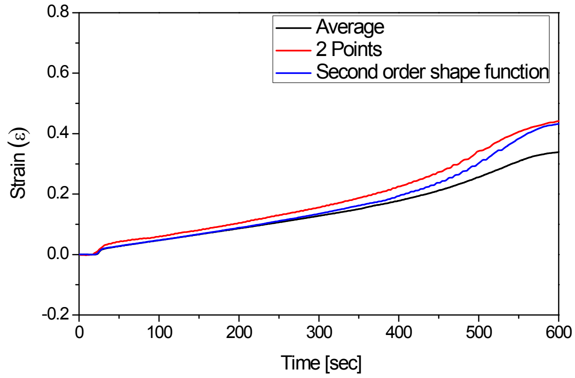

Fig. 6. Strain measurement

3. Conclusions

The strains were measured with various methods using images in coupon test and the measurements were compared. In the future, the validity of the algorithm will be compared using stain gauge and clip gage, and based on the results, the physical properties of materials will be measured using a vision-based measurement system. This will contribute to the evaluation of reliability and effectiveness which are required for investigating local damages. Furthermore, vision-based measurement is a noncontact method that can be used for full field measurements and enable the observation of stress distribution and the progress of defects.

ACKNOWLEDGMENTS

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