A PREDLIMINARY STUDY ON AUTOMATIC INTERVAL MEASUREMENT MODEL FOR JACK SUPPORT

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Abstract

This study proposes a model to measure the installation spacing of jack supports, which play a role in supporting the structure load during construction. The proposed model consists of two parts; one part is the jack support segmentation in an image, and another part is the installation interval measurement. The results of this study contribute to ensuring the construction quality of jack supports and further preventing building collapse accidents. For the further research, we will research the automated camera calibration algorithm to gain the angle and height of the camera.

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Keywords: camera calibration, instance segmentation, jack support, measurement.

1. Introduction

The jack support is widely used one of temporary structures used to prevent collapse accidents at construction and demolition stages [1]. Jack supports must be installed at appropriate intervals after checking the structural design drawing and jack support installation specifications. Compared to the specification, if jack supports are installed at too wide intervals, they cannot support the force, leading to a collapse accident. On the other side, if jack supports are installed at too narrow intervals, costs increase.

The existing method of inspecting the jack supports installation intervals at construction sites is time-consuming work because inspectors have to go to the site and measure the interval between the jack supports by devices like a ruler, but generally check by their eye. In addition, the existing method may lead to a collapse accident due to inaccurate supervision.

Therefore, this paper conducted the preliminary study on the automatic jack support installation interval measurement model using images. The proposed model consists of two parts; one part is the jack support segmentation in an image, and another part is the installation interval measurement. The results of this study can contribute to ensuring the construction quality of jack supports and further preventing building collapse accidents.

2. Methodology

The process of this study is shown in Fig. 1. Instance segmentation was preceded to extract the coordinates of the jack support from the image. In the instance segmentation step, reference points for measuring the distance between jack supports were extracted, and 3D coordinates were converted from 2D coordinates using camera calibration. Finally, the distance between the two reference points in the real world was measured.
2.1. Jack support segmentation

For the jack supports segmentation in image, the recently released YOLOv8 [2] model with the best performance was used. We labelled image dataset with two classes of jack support and background as shown in Fig. 2. In the image segmentation step, jack support coordinate values were extracted. As a reference point for measuring the distance between jack supports, the bottom mid-points of the extracted coordinate values were used as the reference point.

2.2. Measurement

The next step is to measure the distance between the jack supports. It is necessary to convert the 2D points extracted in the previous step to 3D coordinates in the real world. Camera calibration was used to extract the focal length required for conversion into 3D coordinates in units of pixels. The angle and height of the camera required for conversion were measured in advance by installing the camera on a tripod. In order to convert a 2D point \((x, y)\) on the image into a 3D point \((X, Y, Z)\) in a real world, it was calculated as shown in Equations 1 and 2. In here, the \(y\) coordinate representing the height is set to 0 because the bottom point of the jack supports is on the floor.

\[
Z = \frac{z}{y} L
\]  
(1)
\[ X = \frac{\bar{x} Z}{\bar{z}} \]  
\[ (2) \]

\( X \) is a value in a direction of the horizontally across the scene, \( Z \) is a value in a direction of the front of camera, \( L \) is the camera height, \( \bar{x} \) is a horizontal value in image, \( \bar{y} \) is a vertical value in image, and \( \bar{z} \) is a camera focal length.

Finally, the distance \((D_{ij})\) between the reference points \(P_i\) and \(P_j\) of the \(i^{th}\) and \(j^{th}\) jack support was calculated as in Equation 3. \(X_i\) and \(Y_i\) is the 3D coordinate of \(P_i\) in a real world.

\[ D_{ij} = \sqrt{(X_i - X_j)^2 + (Z_i - Z_j)^2} \]  
\[ (3) \]

3. Experimental Study

We tested the validity the proposed model. The accuracy of the jack support segmentation algorithm was tested and then the accuracy of measurement algorithm was tested in the laboratory. Finally, jack supports installation intervals in construction site was measured using the proposed model.

3.1. Test result of jack support segmentation algorithm

To test the effectiveness of the instance segmentation algorithm, jack supports installed in the field were used. First, the 20 datasets for learning the segmentation model were classified into 16 training datasets, 2 validation datasets, and 2 test datasets. The parameters of the learning model were set to 2,000 epochs, batch size to 16, and learning rate to 0.01. As a result of model training, as shown in Fig. 6 below, 1,971 epochs showed the lowest loss and highest precision. In addition, the validation results applied for each epoch showed the best results at 1,971 epochs like the training results. The mAP of the best model was 90.4%.
The test results of the jack support segmentation algorithm is shown in Fig. 6.

3.2. Test result of measurement algorithm

To test the measurement accuracy of the measurement algorithm, the floor tiles of the laboratory corridor were used as target. The measurement test process is as follows. First, mount the smartphone on a tripod at the height of 1.0 m and take a picture in a direction of the front. Measure the height from the floor to the camera lens to convert 2D coordinates to 3D coordinates. Then, calibrate the camera to get the correct focal length. The size of floor tiles has measured a total of 4 times to determine the accuracy of measuring the spacing of corridor tiles using the images. The error rate was calculated by comparing the measured distance with the correct answer distance using the proposed model, and the accuracy was measured by calculating the average error rate. The measured image and the correct answer image are shown in Fig. 7.
A tile size of the corridor was 0.6m, and the test results are as shown in Table 1. When the tile measured by the camera was 3m away, it showed an error rate of -0.3\% at 0.602m, showed an error rate of -0.3\% at 0.592m when it was 3.6m away, and showed an error rate of 0.8\% at 0.595m when it was 4.2m away. When it was 4.8m away, it was 0.592m, showing an error rate of 1.3\%. As a result of the measurement test of the corridor tiles, the measurement accuracy was 99.2\%.

### Table 1. Measurement error rate.

<table>
<thead>
<tr>
<th>Distance from camera</th>
<th>Ground true</th>
<th>Measurement</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>3m</td>
<td>0.6m</td>
<td>0.602m</td>
<td>-0.3%</td>
</tr>
<tr>
<td>3.6m</td>
<td>0.6m</td>
<td>0.592m</td>
<td>1.3%</td>
</tr>
<tr>
<td>4.2m</td>
<td>0.6m</td>
<td>0.595m</td>
<td>0.8%</td>
</tr>
<tr>
<td>4.8m</td>
<td>0.6m</td>
<td>0.592m</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

### 3.3. Test result of the proposed model

To test the effectiveness of the proposed model, we tested the proposed model to the images of jack support installation sites. The focal length was extracted through camera calibration. The angle of the camera was directly measured, and the height of the camera was calculated by measuring from the midpoint of the camera lens to the bottom. And then, jack supports were segmented by the segmentation algorithm and reference points of jack supports were extracted. Finally, the distance was measured based on the reference points by the measure algorithm. The result of measuring the installation interval of the jack support through the proposed model is shown in Fig.8.
4. Conclusions

In this study, an image-based jack support installation interval measurement model was proposed. The proposed model can automatically measure the jack support installation interval from the image. As a result of experimental study, the jack support segmentation algorithm was 90.4% mAP and the accuracy of the measurement algorithm was 99.2%. This result of this study would contribute to prevent collapse accident which may occur due to inaccurate jack support installation. For the further research, we will research the automated camera calibration algorithm to gain the angle and height of the camera.

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