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A Study on the Crack Detection Performance for Learning Structure using Super-Resolution

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ABSTRACT

With the development of industry and technology, the importance of accurate condition checks is increasing in preparation for the deterioration of structures along with the increase in the number of tunnels and underground spaces. However, especially in the case of cracks, there is a problem that the inspection is still carried out in a method that is strongly dependent on human resources, and to overcome this, researches are being actively conducted to detect cracks using computer vision. Since the tunnel is a large-scale infrastructure, crack detection using deep learning in the tunnel must be performed simultaneously with a wide range of analysis and detailed analysis. However, when using the existing segmentation network, it is difficult to satisfy both a wide range and high precision, and it is greatly affected by the quality of the obtained image. Therefore, in this study, we propose a new learning structure based on segmentation using super-resolution, and conduct performance comparison and analysis with the original segmentation network. The learning structure proposed through this study is expected to be able to derive a wider range of analysis with higher precision, and finally, field applicability will be improved.

1. INTRODUCTION

As the importance of underground space was emphasized with the development of industry, many tunnels and underground spaces were constructed. Currently, lots of tunnels are aging, and the number of aged tunnels and underground spaces is expected to increase in the future. Therefore, regular inspection is necessary for safety. However, the current regular inspection is a method directly measured by experts,

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which takes a lot of time and has the disadvantage of difficult to obtain objective results. To solve this problem, research on crack detection using computer vision is in progress.

Tunnels are large infrastructure and extensive and detailed analysis is essential for efficient crack detection. However, there is a problem in that it is difficult to satisfy both aspects at the same time. Analysis of a wide range is difficult because micro cracks are blurred, whereas detailed analysis requires a lot of analysis time. Also, the results are strongly influenced by the quality of the images obtained.

Therefore, in this study, rather than the current crack detection method affected by the image quality, we propose a learning structure that can remove image blur and derive a higher-precision crack detection analysis.

2. LEARNING STRUCTURE

Many studies use segmentation, which is one of the deep learning techniques that utilize images for precise crack detection. (Cao *et al.* 2020, Zhang *et al.* 2018). The most basic autoencoder structure of segmentation used in these studies is shown in Fig. 1 (a).

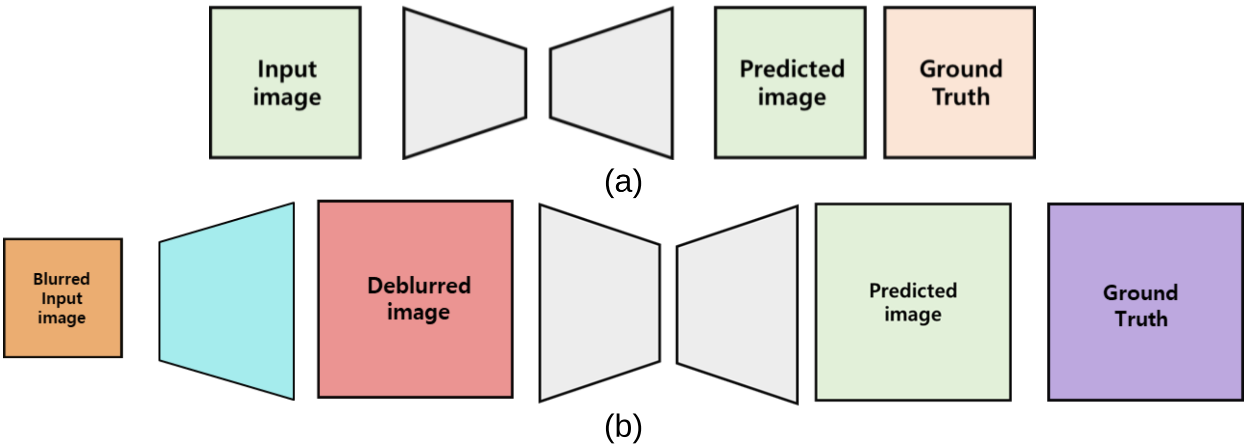


Fig. 1 Architecture of training algorithm; (a) Original. (b) Proposed method

On the contrary, the learning structure presented in this study is shown in Fig. 1 (b). We propose a learning structure that utilizes a blurred image rather than a clean image as training data. Before learning the segmentation algorithm, a deblurred high-resolution image is generated by using a super-resolution algorithm that can also be deblured, which is used for learning the segmentation algorithm. In addition, based on the same existing dataset, segmentation learning was configured to enable more accurate crack detection using a high-resolution dataset that includes the texture of the original data, rather than simply adjusting the size.

3. EXPERIMENTS

3.*1 Datasets*

The same dataset was used for the learning and performance evaluation of each algorithm. A total of 5,356 concrete crack images were used, of which 3,750 were used as learning data, and the remaining 1,606 were used as evaluation data. Open source data were used: SDNET2018 (Maguire *et al.* 2018), Mendeley datasets (Özgenel, 2018), EugenMuller (Morgenthal *et al.* 2014), Volker (Volker *et al.* 2015) etc. In addition, the labeling work for some data and ground truth, which is the labeled data, were converted to the size to be used in this study and further processed to be utilized.

3.*2 Evaluation metrics*

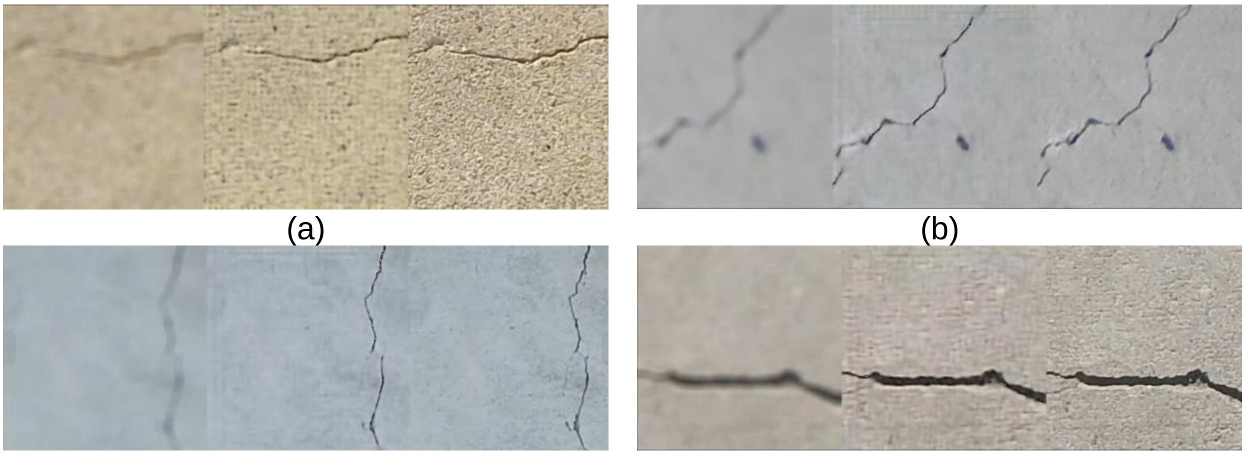
In this study, it is necessary to evaluate two types of algorithms. The first is the evaluation of the performance of the super-solution algorithm that is also capable of deblur processingThe blurred image used as input data was made low-resolution from the existing dataset, and at the same time, a blur filter was arbitrarily applied using the tool provided by OpenCV. The performance evaluation of algorithms to derive deblurred and high-resolution images from processed blurred and low-resolution images is evaluated using SSIM and PSNR, which are widely used for image quality analysis. That is, we evaluated how well it restores clean images from blurry low-resolution images.

The second is the evaluation of the accuracy of the crack detection algorithm. Long *et al.* (2015) presented four metrics to compare and evaluate the accuracy performance of semantic segmentation; pixel accuracy mean accuracy, mean IoU (Intersection of Union) and frequency weighted IoU. In addition to the four widely used indicators of crack detection performance, IoU for cracks was additionally considered. In the case of crack detection, there is a big difference in the degree of distribution of detection targets, unlike conventional semantic segmentation studies. Therefore, it is necessary to additionally consider the detection accuracy of the crack itself rather than the average or weighted average of the detection accuracy of the crack and the background.

4. RESULTS

4.*1 Super resolution and Deblur*

First, SSIM and PSNR were derived from pre-processing images, low-resolution and blurry images, and high-resolution and deblurred images. Based on this value, the deblurred image derived through the super-solution algorithm and the SSIM and PSNR derived from the ground-truth high-resolution and clean images were compared, and improved results were obtained. The comparison result image is shown in Fig. 2. Four representative cases are shown, and each image is a resized image of an input image, a deblurred image derived from super-solution, and a ground-truth (original data) from the left.

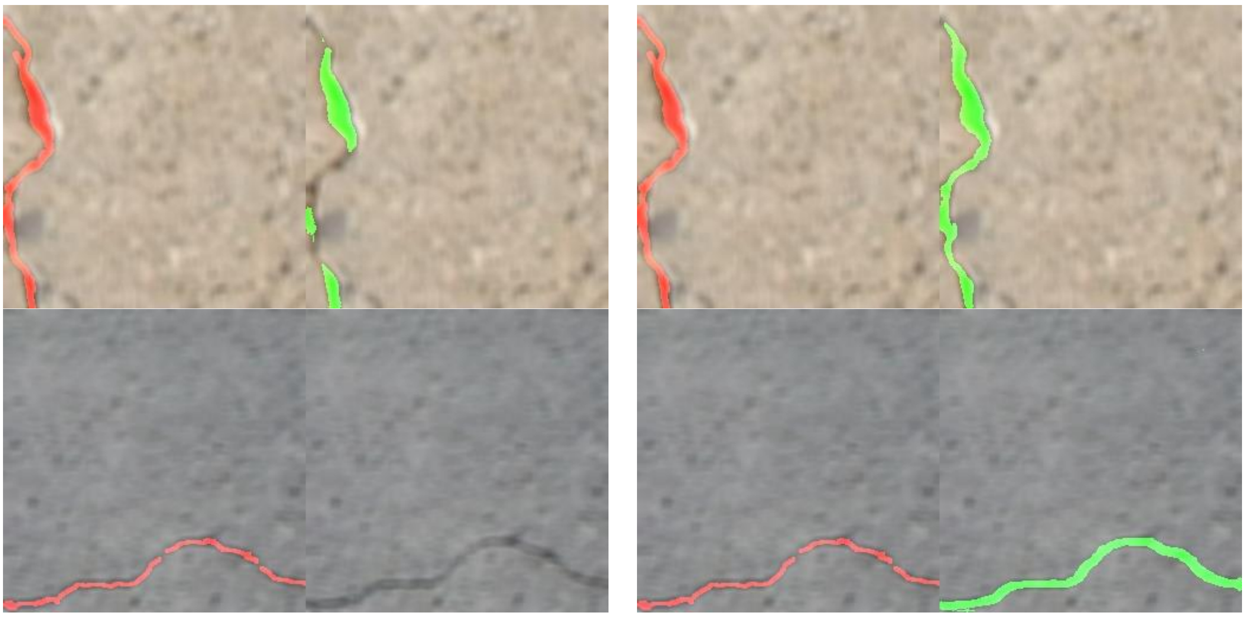


(a) (b) (c) (d)

Fig. 2 Results of super suolution and deblurring; left: blurred and low-resolution image, middle: super-solution and deblurring image, right: high-resolution image.

4.2 Crack detection

The results for crack detection are shown in Fig. 3, and the algorithm used for crack detection in this study is ERFNet (Romera *et al.* (2017). The left side of each image is the ground truth, and the right side is the result derived through the algorithm learned by applying each learning method. Through this, it can be seen that the method presented in this study is capable of more precise crack detection.



(a) (b)

Fig. 3 Results of crack detection; (a) original, (b) proposed method

5. CONCLUSIONS

In summary, crack detection in underground structures such as tunnels requires both extensive and precise analysis at the same time, and the previously studied crack detection algorithm is greatly affected by the quality of the input data. To solve this problem, a new learning method was proposed, and the improved result was confirmed by comparing the accuracy performance with the existing learning method. Through this, it can be seen that the crack detection performance is improved through the change in the configuration of the training data and the learning structure.

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