Quality Control in Civil Engineering Construction Based on Deep Learning

Zhanchun Mu1,*

1School of Yunnan Technology and Business University, Kunming, Yunnan, China

*Corresponding author e-mail: 201708154@bts.ynu.edu.cn

Abstract. In the process of rapid growth of China's construction industry, for civil engineering construction, its construction quality must be guaranteed to be able to drive China's construction industry to the world's advanced level. Based on deep learning, this paper discusses the types of bridges and detects their main components to achieve the quality control of the main components of the bridge. This paper analyzes the quality problems in civil engineering construction, and uses the AlexNet network model in the convolutional neural network to identify the bridge type; Faster R-CNN is used to detect the main components in real time. After testing and verification, the application method proposed in this paper has achieved satisfactory results, and the accuracy of model detection has reached 98.8%. The research in this paper applies advanced science and technology to the field of civil engineering construction to achieve automation and informatization is no longer out of reach, achieve the purpose of construction quality control, and promote the sustainable development of China's construction industry.

Keywords: Deep Learning, Civil Engineering, Engineering Construction, Quality Control

1. Introduction

In recent years, China's urbanization process is accelerating, and civil engineering develops accordingly [1]. In civil engineering construction, the quality of the project is directly related to the safety of people's life and property, as well as the economic and social benefits of the construction unit. Therefore, it is very important to strengthen quality control in project management and construction [2-3]. At present, our country there are still quite a number of building enterprise attaches great importance to the construction schedule and ignore the construction quality, focus on economic benefit, cash flow, and did not have a correct cognition on construction quality control, control the construction quality management in time, also for more extensive management, ignore the fine management, quality control measures is difficult to work [4-5].

By the whole of the project, the many aspects involved in the civil engineering construction management, material procurement, transportation, design, construction plan and drawings, etc., if one link problems, affects the progress of the extremely easily, reduce the engineering quality, quality of civil engineering concern [6-7]. Increasing in recent years, governments and industry to the
construction safety and quality management and investment, but no breakthrough methods, the effect also has no obvious improvement. Therefore, new ideas and new technologies must be adopted to analyze project quality [8-9]. Research on deep learning has been highly valued by researchers in various fields. At present, mainly used in image, speech and natural language recognition field [10]. In this paper, image processing technology based on deep learning theory will be used to detect and study the main components (bridge tower and bridge panel) of the bridge. By enabling the computer to "know" the types of Bridges and position the main components, the construction monitoring and management will be automated, informationized and intelligent, so as to realize the quality control of the main components of the bridge.

This paper discusses the quality control in civil engineering construction based on deep learning. By using AlexNet network model to identify bridge types, Faster r-cnn can detect the main components in real time, so as to achieve the purpose of bridge construction quality control. After verification, the method detection performance is relatively high, which can realize the quality control of bridge main components, to ensure the construction quality to conform to the requirements of the actual construction.

2. Method

2.1. Quality Problems in Civil Engineering Construction

The construction side often only pay attention to the construction speed of construction projects, ignoring the quality of the project. Engineering quality problems can be summarized from several aspects: In order to catch up period, the construction side recruited a large number of construction workers, their technical expertise is its ability to work do not have the required corresponding. Secondly, there is not enough construction material quality assurance. In order to ensure the construction cost of the construction side, choose some cheap construction, the material does not meet the requirements. In the construction project management, regulators are mostly deployed by other departments or temporary employment, professional enough, difficult to effectively control the quality of the project. The safety of bridges in civil engineering is mainly affected by the load-bearing capacity and stability of the main structure. Herein mainly the deck and the pylon two structural members of the bridge is detected, the bridge member in order to achieve the main quality control.

2.2. AlexNet and Faster R-CNN

In this paper, a convolutional neural network in more practical AlexNet network model to identify the type of bridge, mainly refers bridge, suspension, Arch. The main use Faster R-CNN model object detection, the detection bridge, mainly refers pylon, various types of bridge deck of the bridge. All the sample training in this paper is based on 8-layer Alex Net. AlexNet is the champion model of ILSVRC-2012. It is a very representative classic convolutional neural network structure. Fine-tuning AlexNet, weight w update rule is:

\[ w_{i+1} = 0.9 \cdot v_i - 0.005 \cdot \varepsilon \cdot w_i - \varepsilon \cdot \left( \frac{\partial L}{\partial w_i} \right) D_i \]  \hspace{1cm} (1)

\[ W_i + 1 = W_i + V_i + 1 \]  \hspace{1cm} (2)

Faster R-CNN is a fast regional convolutional neural network. Its technical core is called "candidate regional network (RPN)". This structure belongs to a part of convolutional neural network and is responsible for extracting candidate regions. Since this study a small number of training samples, Fast R-CNN and RPN model uses the ZF CNN network having five layers and three convolution fully connected. Studies have shown that the "fast" version of the ZF-net has the fastest
test speed training and can be used for real-time detection. In this study, the improved model for CNN ZF training.

Caffe developed a clear, high readability, fast deep learning framework, this paper, using the C++ language. Caffe support LMDB, LEVELDB and HDF5 three formats input. This article uses LEVELDB, directly using the file convert_imageset.exe program generated by Caffe during the compilation configuration process.

3. Experiment
The pictures used in this article are all from the Internet Baidu search, Google search, Being search, a total of 3832 pictures of arch bridges, suspension bridges and cable-stayed bridges were collected. Comparative common pretreatment: a zero-mean, i.e., by subtracting the mean of 0 so that the average of all pixels of the input image, to obtain a new sample as an input image can be reduced by the larger mean gradients greatly expanded effect. In the image pre-processing stage, the size of all images will be adjusted to $227 \times 227 \times 3$ pixel resolution to fit the input size of AlexNet. To ensure the training process network model is able to run smoothly, it is necessary to provide the necessary high-performance hardware and software environment. As shown herein, the configuration used in Table 1. Network training and testing of this paper were carried out under Windows7 environment.

| Hardware          | The main parameters                                      |
|-------------------|----------------------------------------------------------|
| Computer          | Dell Precision Tower-7810                                |
| CPU               | Intel(R) Xeon @ CPU E5-2630 v4 @ 2.2GHz 32GB             |
| RAM               | ASUS GeForce GTX 1080 Ti                                 |
| GPU               | ATA SK hynix SC300B SCSIDisk Device (512GB)              |
| Hard disk         | ATA TOSHIBA DT01ACA2 SCSI Disk Device (2TB)              |

4. Discussion

4.1. Model Training and Performance Testing
Alex Net trains, verifies, and tests, and records its training loss value and verification accuracy rate every iteration 100 times. The accuracy rate is shown in Figure 1.

![Figure 1. Accuracy change curve](image-url)
The accuracy of verification quickly rises from the initial 27%, with a slight decrease and recovery in the middle. It has basically converged after 10,000 iterations, and the final accuracy of the classifier is stable at 95.75%. The final model is used to classify the test set pictures, and the results are shown in Table 2.

| Table 2. Test results of the bridge classification model |
|--------------------------------------------------------|
| **Kind** | **Number of test sets** | **Accuracy** |
| Arch bridge | 111 | 97.30% |
| Cable-stayed bridge | 100 | 95% |
| Suspension bridge | 83 | 97% |
| Total | 294 | 96.60% |

For binary classification, and based on a relatively small sample size, the accuracy rate of 96.6% is already a very high accuracy rate and can fully meet the application requirements. At the same time, it also verifies that the combination of deep learning image recognition technology for structural type recognition, this application mode is completely feasible.

4.2. Automatic Detection of Main Bridge Components Based on Faster r-Cnn

Select 500 pictures from the data set. Because of the limited number of samples, in accordance with the target requirements and experience, the selected pictures need to meet the requirements of the image format, as well as the side view that can show the positional relationship between the bridge tower and the bridge panel. As far as possible, the structure in the picture is the structure completed by the main body. In the clear picture, the bridge tower or bridge deck is not blocked by a large area. From the sample library of 500 pictures, 405 were selected as training samples, 45 were used as verification samples, and the remaining 50 were used as test samples. After training, the average precision values of the first type of bridge tower and bridge deck are 90.9% and 90.0%, respectively, and the corresponding total average precision value is 90.45%. Due to the particularity of target detection, there will be some special circumstances that reduce the recall rate. In order to better understand the accuracy and promotion of the model, the final model test used was 100 additional pictures selected, of which 174 bridge towers, 106 bridge decks, 169 bridge towers detected, 104 bridge decks, 168 correctly identified bridge towers, 102 bridge decks. The specific results are shown in Table 3.

| Table 3. Recall rate and accuracy rate |
|--------------------------------------|
| **Bridge tower** | **Bridge deck** |
| Recall rate | 96.60% | 96.20% |
| Accuracy | 99.40% | 98.10% |
| Model detection | 96.40% | 98.80% |

From the inspection pictures, it can accurately identify the target components in the elevation pictures after presenting the bridge elevation and tilting at a certain angle. However, the ability of the training model to resist background interference needs to be improved. Taken together, the detection performance and generalizability of the training model are relatively high.

The fundamental contradiction of component identification still exists. The basic basis for the classification of structural components in the field of civil engineering is still their stress situation, but the detection of bridge structural components based on deep learning theory is understood from the perspective of the positional relationship of image representations and shape features. If you want to further popularize and apply image recognition technology based on deep learning to serve the quality management of civil engineering structure construction, you should start by understanding the internal characteristics of the structure.
5. Conclusion

To sum up, strengthening the quality management issues in the construction process of civil engineering can improve the quality standards of the entire project construction. The quality of civil engineering construction will directly affect the quality of construction projects. If there are problems in construction projects, it will threaten people's personal safety and bring serious adverse effects to society. Civil engineering construction enterprises should strictly control construction materials, construction technology and equipment, and construction personnel, and improve related quality assurance mechanisms, strengthen capital management, and refine contract requirements to improve the quality of civil engineering construction. Therefore, in the process of project construction, all-round control is required. With the support of advanced construction technology and high-quality construction personnel, the quality standard of the project is gradually improved. In general, as an effective method to realize artificial intelligence, deep learning provides hope and opportunity for solving problems in the field of civil engineering construction quality control. At the same time, there are huge challenges due to the specificity of the field.

References

[1] Wang S, Zhao S, Al-Qadi I L. Real-Time Density and Thickness Estimation of Thin Asphalt Pavement Overlay During Compaction Using Ground Penetrating Radar Data[J]. Surveys in Geophysics, 2020, 41(3):431-445.

[2] Thulasib S, Unnikrishnan V. Critical factors affecting construction material productivity[J]. International Journal of Civil Engineering and Technology, 2018, 9(6):1123-1130.

[3] Liu X, Hirohata M. Compressive Behavior of Steel Members Reinforced by Patch Plate with Welding and Bonding[J]. Open Journal of Civil Engineering, 2018, 8(4):341-357.

[4] Balamurali S, Baranitharan B. An Improved System of Skip-Lot Acceptance Sampling Plans for Highway Construction and Materials[J]. Journal of The Institution of Engineers (India), 2019, 100(1):9-19.

[5] Kdiri Q, Krasniqi C. Force based design versus displacement based design method for wall structures[J]. International Journal of Civil Engineering & Technology, 2018, 9(3):292-304.

[6] Chanu N M, Nanda R P. A Proposed Rapid Visual Screening Procedure for Developing Countries[J]. International journal of geotechnical earthquake engineering, 2018, 9(2):38-45.

[7] Malanda N, Louzolo-Kimbembe P, Ahouet L, et al. Concrete Formulation Study for Informal and Semi-Informal Construction Sectors[J]. Open Journal of Civil Engineering, 2019, 9(1):57-79.

[8] Koopialipoor M, Nikouei S S, Marto A, et al. Predicting tunnel boring machine performance through a new model based on the group method of data handling[J]. Bulletin of Engineering Geology & the Environment, 2019, 78(5):3799-3813.

[9] Paul S C, Tay Y W D, Panda B, et al. Fresh and hardened properties of 3D printable cementitious materials for building and construction[J]. Archives of Civil & Mechanical Engineering, 2018, 18(1):311-319.

[10] Zou G F, Fu G X, Gao M L, et al. A novel construction method of convolutional neural network model based on data-driven[J]. Multimedia Tools and Applications, 2019, 78(6):6969-6987.