Casting-RCG and GRImage-Net: Generation of Casting Flaw Detection Image and Defect Intelligent Detection

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Abstract: The automatic defect detection of casting X-ray inspection images based on deep learning has the problems of single defect sample topography and poor network generalization. Therefore, the research on casting inspection image generation and multi-source image deep feature fusion defect detection is carried out. Firstly, a defect image simulation generation model based on RCG (Casting-RCG) was constructed, and a quasi-unconditional generation framework was built according to the defect features, which realized the high-quality generation of multiple defects such as shrinkage holes in Casting inspection images. Secondly, a defect localization and classification network based on deep feature fusion of generated images and real images (GRImage-Net) was created, and ablation experiments were carried out to verify the performance of the network. The results show that GRImage-Net based on Casting-RCG can significantly improve the accuracy, precision and recall rate of defect detection. It has better generalization than the single feature input model. The Casting-RCG and GRImage-Net created in this paper provide a new way to enrich the defect morphology and improve the generalization of the network, which has important theoretical guidance and engineering application value.

Keywords: casting; defect detection; flaw detection image; generation; deep feature fusion

1 Introduction

X-ray defect detection of castings is an important means to detect the internal defects of castings [1]. The traditional manual detection method is inefficient and easily affected by subjective factors [2]. In recent years, deep learning technology has made significant progress in the field of image processing, and automatic detection methods based on deep learning are gradually applied to defect detection of X-ray inspection images of castings [3]. However, there are two main problems with existing methods:

Single defect sample topography: Due to the difficulty of obtaining defect samples and the limited types of defect topography in the existing data set, the trained model does not perform well in the face of new types of defects.

Poor network generalization: The model performs well on the training data, but its performance is unstable on the test data or real-world applications, and it is difficult to generalize the application.

In order to solve these problems, this study proposes a defect detection method combining defect image simulation generation and multi-source image deep feature fusion, aiming to improve the detection ability and generalization of the model.

2 Experimental procedure

(1) as shown in Figure 1. The defect image simulation generation model (Casting-RCG) is constructed. In order to generate high-quality defect images with various morphologies, a defect image generation model based on RCG (Random Conditional Generative) is constructed. The model is implemented by the following steps.

Data collection and preprocessing: The real casting X-ray inspection images are collected and preprocessed, such as denoising and normalization.

defect feature extraction: Convolutional Neural Network (CNN) was used to extract the features of different types of defects and construct a feature library.

Simulation generation model construction: Based on the RCG framework, combined with the extracted defect features, the defect images of various morphologies are generated. RCG model achieves high-quality simulation generation of different defect morphologies by introducing random noise and conditional constraints.

(2) Build a fault localization and classification network (GRImage-Net). In the defect detection stage, a defect localization and classification network (GRImage-Net) based on deep feature fusion of generated images and real images is established. The specific steps are as follows.

Feature extraction network: Design a deep convolutional neural network for extracting deep features of real and generated images.

Feature fusion module: The extracted deep features are fused, including feature stitching and attention mechanism, to enhance the feature representation ability.

Defect localization and classification: through multi-layer convolution and pooling operation, the precise localization and classification of defects are realized.

(3) Ablation experiments were carried out for verification. To verify the performance of GRImage-Net, we design the following ablation experiments.

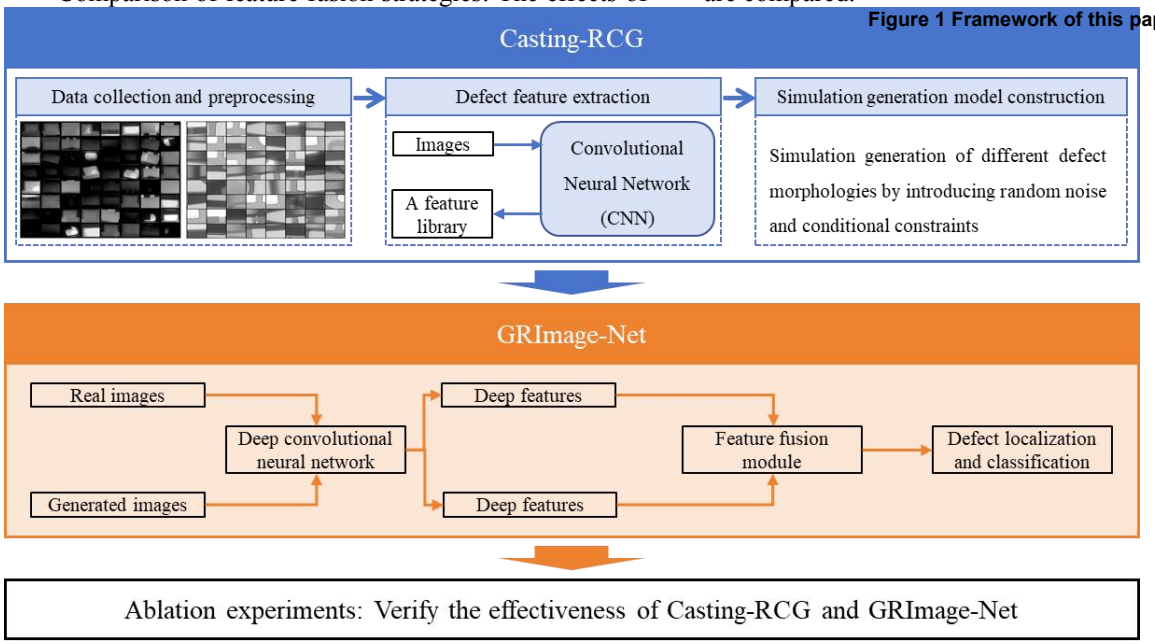
Single feature input model: only real images or generated images are used for training and testing.

Multi-source image feature fusion model: combining the

deep features of real images and generated images for training and testing.

Comparison of feature fusion strategies: The effects of different feature fusion strategies (such as simple concatenation, weighted fusion, and attention mechanism) are compared.

Figure 1 Framework of this paper



3 Result and discussion

The model is expected to achieve the following:

Defect image generation quality: Casting-RCG is able to generate high-quality defect images of various morphologies, and these generated images are visually very close to the real defect images, providing rich samples for network training.

Defect Detection Performance: GRImage-Net is expected to achieve significant gains in accuracy, precision, and recall for defect detection compared to models trained using only real images.

Generalization: GRImage-Net is expected to perform better than traditional models on different datasets, and the network may have better generalization and be able to maintain high detection performance in different detection tasks.

4 Conclusion

In this paper, a defect image simulation generation model based on RCG (Casting-RCG) and a defect detection network based on deep feature fusion of generated images and real images (GRImage-Net) are proposed, which can effectively solve the problems of single defect sample topography and poor network generalization. The experimental results are expected to be realized: high-quality defect images generated by Casting-RCG provide rich samples for network training, and GRImage-Net significantly improves the performance and generalization of defect detection through multi-source image deep feature fusion. The research in this paper provides a new method and idea for casting X-ray flaw detection image defect detection, which has important theoretical and practical application value.

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