論 文 の 内 容 の 要 旨

論文題目　A Ceiling Damage Detection System Using Deep Learning Approach (Convolutional Neural Networks)
（深層学習（畳み込みニューラルネットワーク）による天井被害検出システム）

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The large span buildings are employed as shelters for residents when earthquake or other disasters occur in Japan. Falling of the ceiling boards or other hanging components in these buildings usually happens in a sudden and are dangerous to human body, especially when residents huddling together during a disaster. Nowadays, damage detection task to the ceilings is mainly relied on human naked eyes, especially on those who are specialists in architecture or trained for this task. The current damage detection method is consumption of labors and inefficient. This task is possible to be converted into image recognition task with in the background that the deep learning method, especially the convolutional neural networks (CNN) have achieved astonishing achievements in recent years. A ceiling damage detection system is built in this thesis using convolutional neural networks to aid human in daily ceiling maintenance and in refuge ceiling safety judgement under emergency.

In this thesis, the following works have been done:

Chapter 1 introduces the background of ceiling damage detection and machine learning, the prospect of the application of machine learning into ceiling damage detection, the research objectives and the outline of this thesis.

Chapter 2 explains the deep learning and convolutional neural networks in theory. The mathematical calculations and mechanisms are introduced to build the calculation foundation to this thesis.

Chapter 3 describes the generation of a CNN model for ceiling damage evaluation. In this chapter, the datasets under the label criteria specialized for deep learning are labeled by human firstly. Then a CNN model is built and trained from scratch using countermeasures to overfit. Finally, the trained CNN model is tested and reaches a relatively high accuracy in prediction.

Chapter 4 investigates the trained CNN model to reveal the mechanisms of the prediction process. In this chapter, the trained CNN model is demonstrated from many visualization perspectives: Firstly, the outputs of the intermediate convolutional layers are visualized to grasp basic perceptive interpretations of the notions the model has learnt; Secondly, the activation maps to the filters are visualized to show what the CNN model has learnt through the gradual abstractions among the convolutional layers; Thirdly, the saliency maps and the Grad-CAM methods are used to visualize the pixels those contribute most to the final prediction to a given image. The visualization to these pixels does not only confirm that the CNN model has learnt the 'intact' and 'damaged' notions, but also provide the solutions to ceiling damage detection. Finally, a ceiling damage detection system using the blocks of CNN mode generation and visualization is raised to provide aid to both professionals of ceiling structures and common users.

Chapter 5 provides the implementations of pretrained CNN models for ceiling damage detection. Firstly, two new CNN models (transfer learning models) using the trunks of VGG16 and VGG19 are built and trained for ceiling damage detection to relatively high accuracies. Secondly, the visualization for the final two prediction nodes are visualized to confirm that the transfer learning models have learnt the most important features of intact and damaged ceilings. Thirdly, the saliency map and Grad-CAM of these two models are visualized to confirm that the transfer learning models can learn faster and better than the CNN model built from scratch. The transfer learning is an improvement to the previous model. Finally, a ceiling damage detection system using transfer learning is raised.

Chapter 6 concludes the main conclusions in this thesis and looks into future research on applying deep learning in ceiling damage detection.