ABSTRACT

Author: Zhang, Yuxi. Master
Institution: Purdue University
Degree Received: August 2019
Title: CNN-based Symbol Recognition and Detection in Piping Drawings
Major Professor: Hubo Cai

Piping is an essential component in buildings, and its as-built information is critical to facility management tasks. Manually extracting piping information from legacy drawings that are in paper, PDF, or image format is mentally exerting, time-consuming, and error-prone. Symbol recognition and detection are core problems in the computer-based interpretation of piping drawings, and the main technical challenge is to determine robust features that are invariant to scaling, rotation, and translation. This thesis aims to automatically extract features from raw images, and consequently, to recognize and locate symbols in piping drawings using convolutional neural networks (CNNs).

In this thesis, the Spatial Transformer Network (STN) is applied to improve the performance of a standard CNN model for recognizing piping symbols, and the Faster Region-based Convolutional Neural Network (Faster RCNN) is adopted to explore its ability in symbol detection. For experimentations, the synthetic data is generated by the following process. Two datasets are generated for symbol recognition and detection, respectively. For recognition, eight types of symbols are synthesized based on the geometric constraints between the primitives. The drawing samples for detection are manually sketched using AutoCAD MEP software and its piping component library, and seven types of symbols are selected to explore the potential limitations in using the Faster RCNN model. Both sets of samples are augmented with various scales, rotations, and random noises.

The experiment for symbol recognition is conducted by comparing the recognition accuracy of the CNN + STN model and the standard CNN model. It is concluded that

the spatial transformer layer can improve the accuracy in classifying piping symbols. Besides, the model performance in learning rotation-invariant features is evaluated by measuring the linearity by rotating samples. The results show that the spatial transformer module can facilitate CNN to learn rotation-invariant representations, which may be the reason for the accuracy boost. For the symbol detection task, the main evaluation matrix is the mean Average Precision (mAP) when Intersection over Union (IoU) threshold equals to 0.5, and this model yields an acceptable result. Based on the results of Average Precision (AP), the finding is that imbalanced data will result in a problem, which needs to be considered in further work. Meanwhile, based on the comparison of true positive and false positive samples, it is observed that the same component in different symbols may increase the risk of false positives.