Machine Learning Engineer Nanodegree

Capstone Proposal

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March 09, 2018

Proposal

Domain Background

In real-life, people take amounts of photos for different goals every day. However, how to efficiently recognize or classify these photos is a important issue. With the improvement of Machine Learning, it has been found that Neural Networks which is a kind of model of deep learning have a dramatic impact on image recognition or classification. Even a simple model of Neural Networks is able to arrive a high accuracy for image prediction on most datasets from a variety of areas.

In industry, it is troublesome problem to find out which root cause which lead products to appear defects. To solve this issue, the first step is that classify the images taken from machine in manufacturing process which could help us understand how many types of defects have been produced.

Traditional approaches to classify defect images is Supervised Learning[1]. First the features of each type of defects need to be defined by humans to help model distinguish different types of defects effectively. Then detect where the defects locate. Finally recognize which type these defects belong to.

Problem Statement

It exists a serious issue if using supervised model to classify defect images. Because each type of defects require to be defined the specific features to recognize them, the model could not classify these images effectively if a new type of defects appears.

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1 Q. Shubo, G. Shuai and Z. Tongxing, "Research on Paper Defects Recognition Based on SVM," *2010 WASE International Conference on Information Engineering*, Beidaihe, Hebei, 2010, pp. 177-180.

The goal of this project is to train a deep learning model that is able to classify a defect image automatically even if it does not belong to existed classes. Then the model could distinguish different types of defects precisely, which means it would have a high accuracy.

Datasets and Inputs

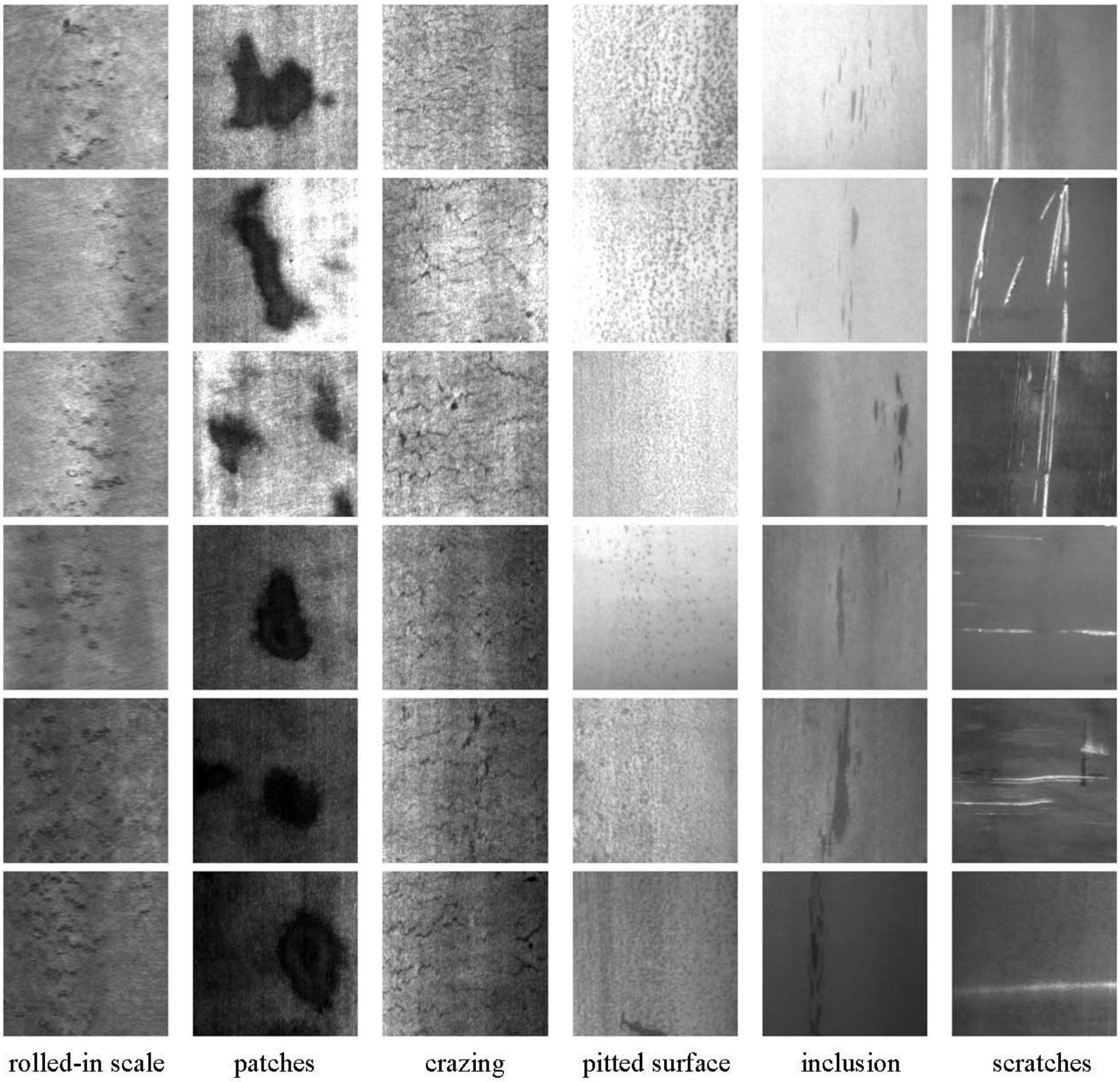

Fig. 1: NEU-CLS

This project will adopt steel surface defect database from Northeastern University (NEU)[2]. The database includes 1,800 grayscale images which contain six kinds of

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2 Song, K., and Yan, Y., "A noise robust method based on completed local binary patterns for hot-rolled steel strip surface defects," *Applied Surface Science*, vol. 285, pp. 858-864, 2013.

typical surface defects of the hot-rolled steel strip, i.e., rolled-in scale (RS), patches (Pa), crazing (Cr), pitted surface (PS), inclusion (In) and scratched (Sc), and each kind of defect owns 300 samples.

In Fig. 1[3], it shows the sample image of six kind of typical surface defects, and the original resolution of each image is 200*200 pixels. Through observing these images, this project may face two difficult challenges, i.e., these intra-class, the same kind of defects, have similar aspects but some of them exist large differences in appearance in the meanwhile which means that the kind of defects is difficult to be defined by features, the defect images suffer from the impact of illumination and material changes.

Solution Statement

Neural Networks (NNs) could effectively find out feature patterns for each type of defects automatically instead of human definition. Higher-level features are class-sensitive but lower-level features are generic. Convolutional Neural Networks (CNNs) which is a special instance of NNs is sensitive to local receptive field by sparsely connected to a small set of neurons and reduce the computation complexity efficiently. In addition, data augmentation which is used to increase the amount of training samples could not only solve the insufficient dataset but also reduce the generalization error without influencing the effective capacity.

As a result, a CNNs model with data augmentation would be built to classify these defect images effectively.

Benchmark Model

RESNET, Inception-V3, VGG-16 pre-trained on imagenet challenge[4] are well-known networks. This project would adopt transfer learning technique which use the weights from above mentioned pre-trained networks on large dataset to recognize these steel surface defect images as benchmark model.

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3 NEU surface defect database: http://faculty.neu.edu.cn/yunhyan/NEU_surface_defect_database.html

4 ImageNet Large Scale Visual Recognition Competition (ILSVRC): www.image-net.org/challenges/LSVRC/

Evaluation Metrics

The evaluation metric for the model will be accuracy on the test images which are split from NEU steel surface defect database.

$$accuracy = \frac{number\ of\ testing\ images\ which\ are\ classified\ correctly}{number\ of\ testing\ images}$$

Project Design

The first step of this project is preprocess the NEU steel surface defect database.
* Digitize the labels (from one to six)
* Resize the images
* Data augmentation
* Split database into training data and testing data

Then build a Convolutional Neural Networks model which would consist of several convolution layers which may followed by pooling, normalization or dropout layers, using sigmoid or ReLU function as activation function and finally end in six softmax classifier.

The final evaluation of the model is determined by computing the accuracy of the predictions for the testing dataset. N-fold cross validation would be used to evaluate changes to the model's parameters, which could avoid overfitting.