The paper: WINTER ROAD SURFACE CONDITION RECOGNITION USING A PRE-TRAINED DEEP CONVOLUTIONAL NEURAL NETWORK (2018) by Guangyuan Pan (2018)

OBJECTIVE:

This paper investigates the application of the latest machine learning technique – deep neural networks for CLASSIFYING ROAD SURFACE CONDITIONS (RSC) based on images from smartphones. The previous application using Random Forest(RF) – Support vector machine(SVM) are not good because of image noise.

METHOD

In the proposed approach, it is introduced the idea of applying an existing CNN model that has been pre-trained using millions of images with proven high recognition accuracy as well as unfreezing the last three layer for feature extraction. Then, the model is extended with two additional FCN for learning the specific features of the RSC images. The whole model is then trained with a low learning rate for fine-tuning by using a small set of RSC images. The testing accuracy with different training dataset sizes is also analyzed, showing the potential of achieving much higher accuracy with a larger training dataset.

MODEL ARCHITECH:

- Input image (150,150,3)

- VGG16-Feature-Extraction layer

- 2 Fully connected Networks for classifier

- Optimizer: stochastic gradient descent (SGD) with learning rate 0.001 and fine- tuning learning rate is 0.005 (hyper parameter tuning)

- Update the weight of last three and top-level classifier and freeze the rest

- Metrics: False Positive rate, False Negative rate, Accuracy

RESULT:

- The results are discussed with respect to RSC classification schemes under three different levels of granularity, namely, two classes, three classes and five classes.

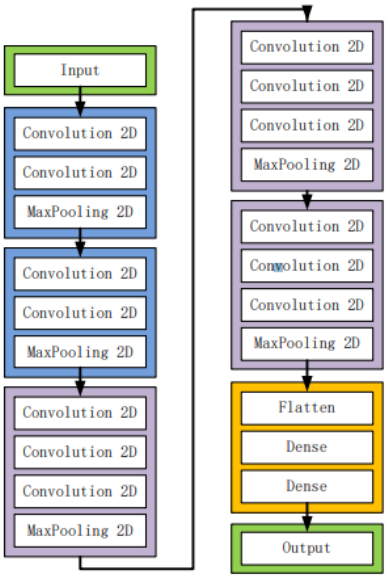

Figure 1: Vgg16 and 2 proposed FCN

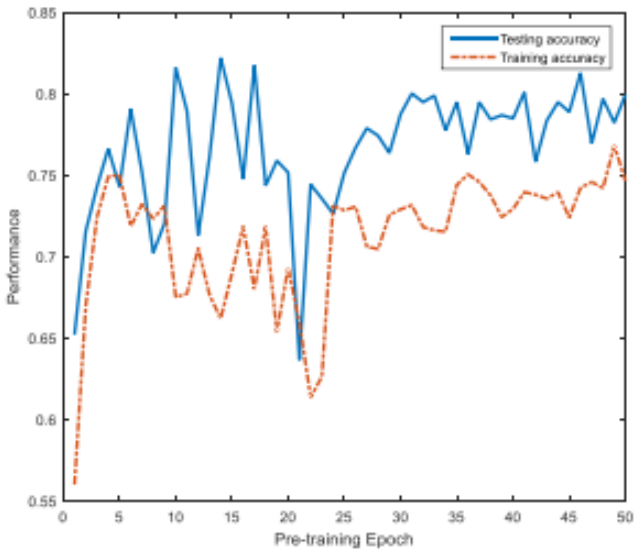

Figure 2: Training and testing accuracy of pre-trained model

Figure 2 shows the training and testing accuracy in each epoch for pre-training steps. In pre-training, the training accuracy starts at 56%, and reaches 75-77% after 50 epochs. The testing accuracy is generally higher than training performance, and it achieves over 80% accuracy after 50 epochs.

TABLE 2 Two-class Description Testing Result

Ground Truth	False positive	Examples
With snow coverage 55.39%	4.87%	
Without snow coverage 44.61%	14.75%	
Overall Accuracy	90.72%	

False positive rate is another important measure of model performance, which is defined as the proportion of cases that road surfaces are in snow/ice presence conditions but are classified as bare pavement. From Table 2, for a bare surface, a false positive occurs when the model incorrectly classifies a bare surface as with snow covered, or vice versa. In the one hand, the implication of a high false positive for bare conditions is therefore a compromise in safety. On the other hand, the false positive of with snow covered detection has lower safety but higher risk of maintenance resource wastage due to false responses of incorrect classifications. Therefore, false positive for bare conditions is considered most critical.

Table: 3 Performance Comparison of Models

Models	Accuracy
CNN	88,4%
Pre-trained CNN	90,7 %

The table shows that using pre-trained CNN helps increase the accuracy while limiting the time for large training data collection and computational time, which is the best approach for time limit and computational capacity

PROS:

- Reducing the needs for large training data and computational time

- Outperforming the traditional machine learning

- Using the raw image data without pre-processing as required by most traditional approaches

CONS:

- The robustness of the model performance to network structure needs to be further investigated (further using Inception-3 and deep residual learning method)

- The need to adapt network structure to increased data size

- Exploring the generality of the proposed method and model for a variety of images (dashboard camera or traffic cameras)

Why this publication was interesting you?

Based on the summary publication, this approach is totally suitable for road-field classification issues (time limit and the lack of training images), which is a common issue for classification problems, nowadays. Therefore, it interested me because of its practicalness, and implementing it could help me solve the issues in road-field classification.