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Deep learning-based Stain/occlusion Detection for Onboard Vision Systems

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BACKGROUND

Onboard camera is widely used for ADAS (Advanced Driver Assistant System) and autonomous driving systems. However, as a vehicle operates on different conditions, camera lens may get stains (such as mud, oil, etc.) on top of it. In such case, a stain/occlusion-recognition algorithm is needed to enable the wiper to clean the lens in different ways according to the type of stains .

In this research, we are provided with collected real videos, we extract images from videos and label them. Then we learn some classification CNN (convolutional neural networks) and implement advanced deep learning algorithm (such as DenseNet, ShuffleNet) to recognize stained images. In order to make the algorithm realizable on the driving system, we should both pay attention to the accuracy and time response.

DATASET BUILDING

Extraction

We make a screenshot automatically every 10 frames for each video.

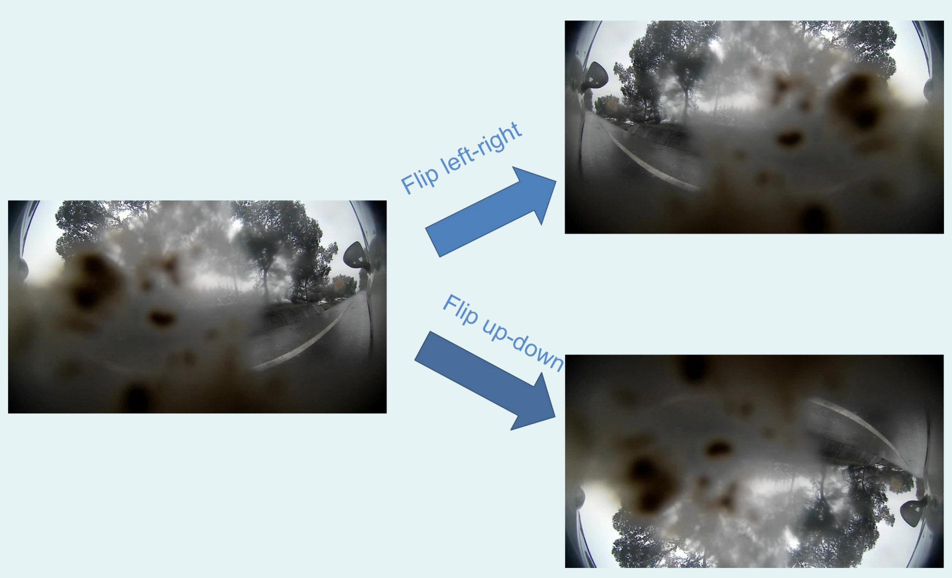
Classification

We divide images into 6 types according to different modes of clean after recognition.

Dataset Augmentation

For some similar images we randomly flip them up-down or left-right in order to improve generalization ability of the model.

Training set consists of **12000** images
Testing set consists of **2400** images



Generalization ability improvement

OBJECTIVE

Illustration of stains

- ***Image extraction***:
  Extract a enormous number of images from videos
- ***Image classification***:
  Build our training set and testing set.
- ***Algorithm implementation:***
  Implement algorithm on platform TensorFlow
- ***Train and evaluate models***.
  Acquire relatively high accuracy and short response time.
- ***Result comparation***
  Compare performances of models and conclude.

DenseNet

Generally, deeper a convolutional networks is, more accurate it could be. However, information could vanish by the time it reaches the end (or beginning) of the network.

One possible method is to create short paths from early layers to later layers.

DenseNet applies this idea. Compared with other deep CNN, it has several strengths:

1. **Relatively fewer parameters** for comparable accuracy.
2. it connects all matching layers directly with each other, which ensures **maximum information flow** between layers.
3. It has a regularizing effect, which makes it **easier to train.**
4. It **relieves** problems of **gradient vanishing** and **model degradation**

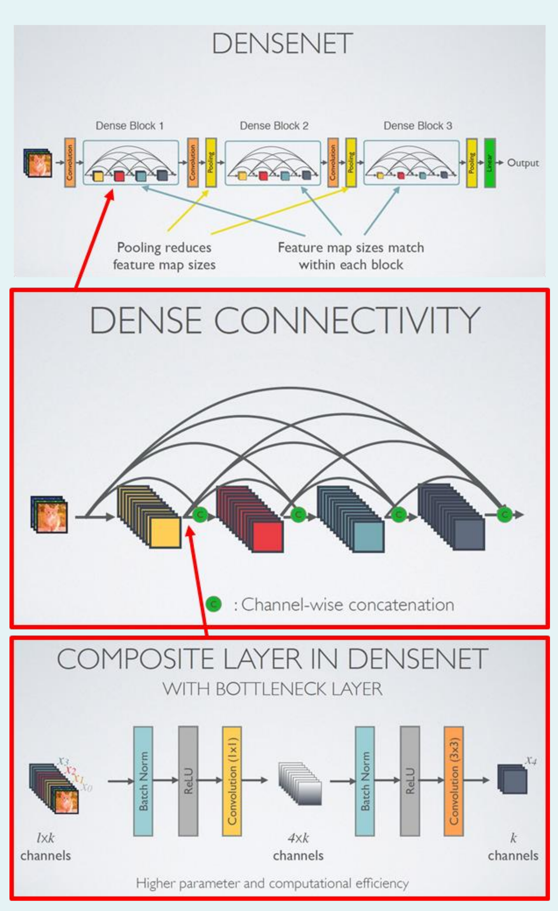


Illustration of DenseNet

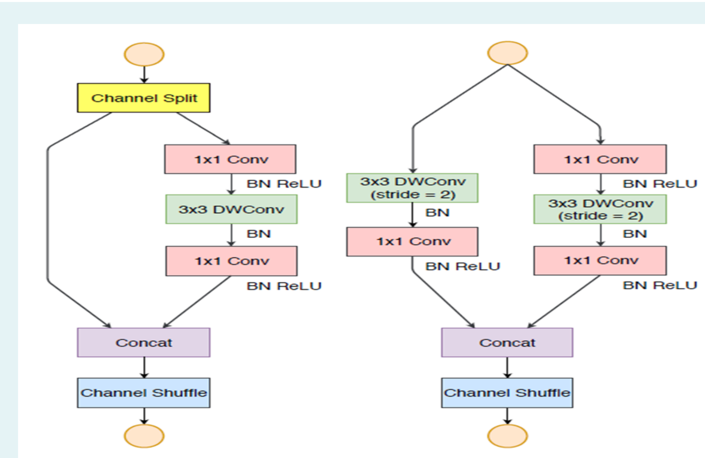
ShuffleNet

Besides accuracy, speed is another important consideration. Real world tasks often aim at obtaining best accuracy under a limited time and computational budget. Therefore, lightweight architectures are motivated

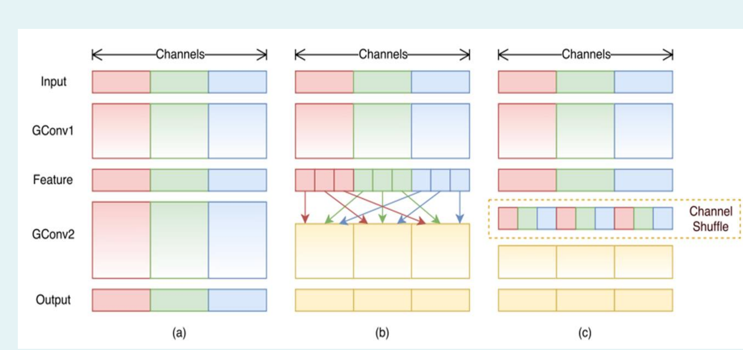
Small convolution, especially 1*1 convolution has been proved to be a good way to be 'light', but always companied with troubling computation complexity

ShuffleNet propose 2 methods to deal with it:

1. **Pointwise group convolution,** which helps to reduce computation complexity.
2. **Channel shuffle**, which reduces the loss of information owing to the group convolution.



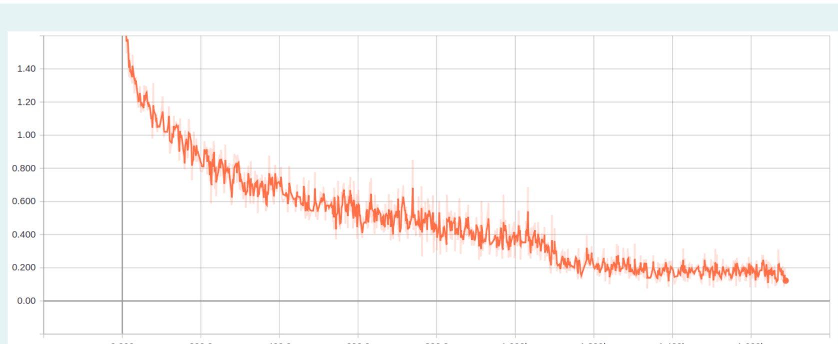
SHuffleNet unit



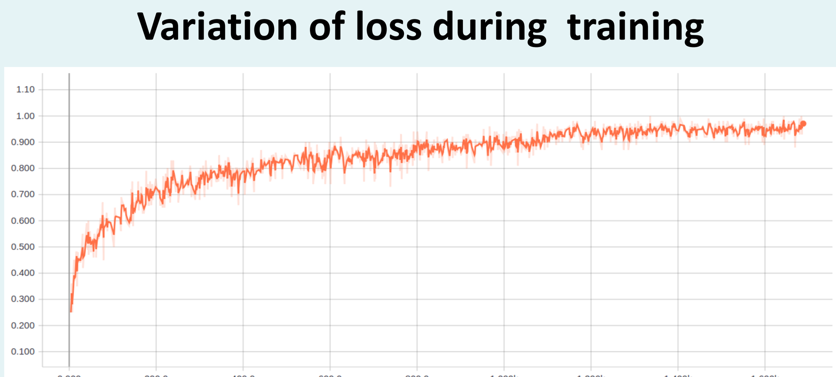
Channel shuffle

RESULT

Result	DenseNet No.3	ShuffleNet 1.5 ×
Train Accuracy	0.9504	0.9282
Train Loss	0.1748	0.2361
Test Accuracy	0.9363	0.9065
Test Loss	0.1944	0.2709
Test Time (s/2000 pics)	83.90	71.54



Variation of loss during training



Variation of accuracy during training

FURTHER STUDY

- ***Vehicle testing***:
  After transplant of algorithm on vehicle, we are going to test and improve the availability of our algorithm in real condition.
- ***Lightweight network***
  In order to improve the instantaneity of algorithm, we are going to trying lightweight network with nice accuracy.
- ***Dataset expansion***
  We are going to train our algorithm with more types of stain and in more different environments to achieve a better performance.