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Deep convolutional neural networks for fine-grained car model classification

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Abstract. This paper describes an end-to-end training methodology for CNN-based fine-grained vehicle model classification. The method relies exclusively on images, without using complicated architectures. No extra annotations, pose normalization or part localization are needed. Different full CNN models are trained and validated using CompCars [3] dataset, for a total of 431 different car models. We obtained a top-1 accuracy of 97.62% which outperforms previous works substantially.

Keywords: Vehicle model · fine-grained classification · CNNs.

1 Introduction

Fine-grained classification of cars has great interest for a considerable number of applications. This task can be extremely challenging due to big similarities and subtle differences between related car models including changes in location, viewpoint or pose. Previous works make use of pose normalization, part localization [2] and modeling [1] or additional annotations which brings complex models and tedious elaborated datasets. We propose to train an end-to-end system for fine-grained car model classification using CompCars [3]. We used the classification subset, which contains 44.481 images from 431 different car models, divided into 70% for training and 30% for test.

2 System Description and Results

Three base models have been used (ResNet50, ResNet101 and InceptionV3) [4, 5] with a variety of training configurations, including data augmentation, different fine-tuning strategies and learning rate policies. Images are resized to 224x224/229x229 pixels (ResNet/InceptionV3) and randomly augmented including horizontal flip, noise, blur, shear, color casting and color jittering. Two fine-tuning strategies were adopted. First, fine-tuning the pre-trained Imagenet [6] models. Second, a two step fine-tuning process that consists of first training the fully connected part and after that the full network. Regarding learning rate policies two strategies were adopted: constant learning rate and to use a higher learning rate at the beginning and step it down by a factor of 10 every 10 epochs. The use of data augmentation considerably improves the performance. Best results were achieved when using simultaneously data augmentation, two step fine-tuning method and adaptive learning rate (see Table 1).

Model	Data aug.	fine-tunning	lr policy	Top1/5 accuracy (%)
ResNet50	/	full	constant	88.48/97.44
ResNet50	Yes	full	constant	95.48/99.26
ResNet50	Yes	full	step-10	97.03/99.62
ResNet50	Yes	2-step	both	97.16/99.60
ResNet101	Yes	2-step	both	97.59/99.68
InceptionV3	Yes	2-step	step-10	**97.62/99.64**
GoogLeNet [3]	/	/	/	91.20/98.10

Table 1. Classification accuracy of different experiments.

Fig. 1. Classification results: 3 correct classifications (left) and 1 error (right).

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