

Interim report on Automotive Surveillance.

BOUNDING BOX REGRESSION AND MULTICLASS CLASSIFICATION OF STANFORD CAR IMAGES

Submitted by - AIML Batch-B Jan, 21

Members - Ambika, Kishore, Nitya, Rohith, Sushweta

LIST OF ACRONYMS AND ABBREVIATIONS

DL - Deep learning

CNN - Convolutional neural network

IOU - Intersection over union

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SECTION 1: INTRODUCTION

Summary of problem statement

The Stanford Cars dataset consists of 196 classes of cars with a total of 16,185 images. The data is divided into almost a 50-50 train/test split with 8,144 training images and 8,041 testing images. Categories are typically at the level of Make, Model, Year. The images are of varying dimensions

The Objective of Multi-class object detection, implies that we are trying to

- (1) detect where an object is in an input image [Bounding box]
- (2) predict what the detected object is [Class].

Data description

The dataset directory contains two subdirectories, annotations (Train and Test) and images (Train and Test) and a dictionary file.

Train Images: Consists of real images of cars as per the make and year of the car.

Test Images: Consists of real images of cars as per the make and year of the car.

Train Annotation: CSV file consists of bounding box regions for training images.

Test Annotation: CSV file consists of bounding box regions for testing images.

Car Name and Make csv file consists of dictionary mapping between class number and class name.


SECTION 2: DATA ANALYSIS AND PRE-PROCESSING

Approach to EDA

The dataset is a set of images segregated as train and test samples. Train Images have 8144 images which are related to cars of different models. Test Images have 8041 images which are related to cars of different models. There are 196 classes of cars. Given the number of images, the dataset is almost equally divided as train and test set. Both sets have 196 classes of cars.

Class having minimum number of images in train dataset

Below mentioned picture shows 5 classes which are having less number of images in the Train dataset.



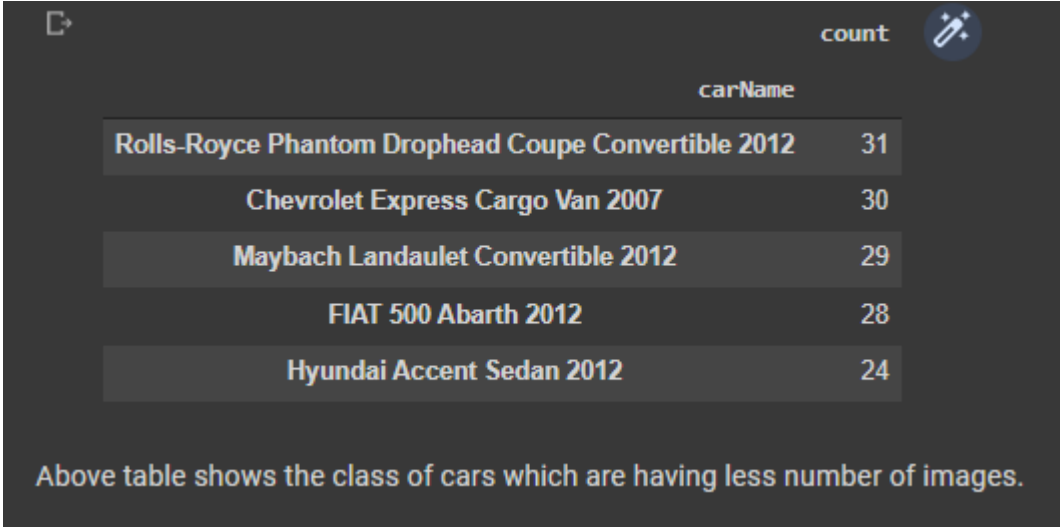
The screenshot shows a Jupyter Notebook interface with a table. The table has two columns: 'carName' and 'count'. The data is as follows:

carName	count
Rolls-Royce Phantom Drophead Coupe Convertible 2012	31
Chevrolet Express Cargo Van 2007	30
Maybach Landaulet Convertible 2012	29
FIAT 500 Abarth 2012	28
Hyundai Accent Sedan 2012	24

Above table shows the class of cars which are having less number of images.

Class having maximum number of images in train dataset

Below mentioned picture shows 5 classes which are having less number of images in the Train dataset.



A screenshot of a table with a dark background. The table has two columns: 'carName' and 'count'. It lists five car models and their corresponding image counts. The counts are 31, 30, 29, 28, and 24 respectively. Below the table, there is a text caption.

carName	count
Rolls-Royce Phantom Drophead Coupe Convertible 2012	31
Chevrolet Express Cargo Van 2007	30
Maybach Landaulet Convertible 2012	29
FIAT 500 Abarth 2012	28
Hyundai Accent Sedan 2012	24

Above table shows the class of cars which are having less number of images.

Class having minimum number of images in test dataset

Below mentioned picture shows 5 classes which are having less number of images in the Test dataset.



A screenshot of a table with a dark background. The table has two columns: 'carName' and 'count'. It lists five car models and their corresponding image counts. The counts are 30, 29, 29, 27, and 24 respectively.

carName	count
Rolls-Royce Phantom Drophead Coupe Convertible 2012	30
Chevrolet Express Cargo Van 2007	29
Maybach Landaulet Convertible 2012	29
FIAT 500 Abarth 2012	27
Hyundai Accent Sedan 2012	24

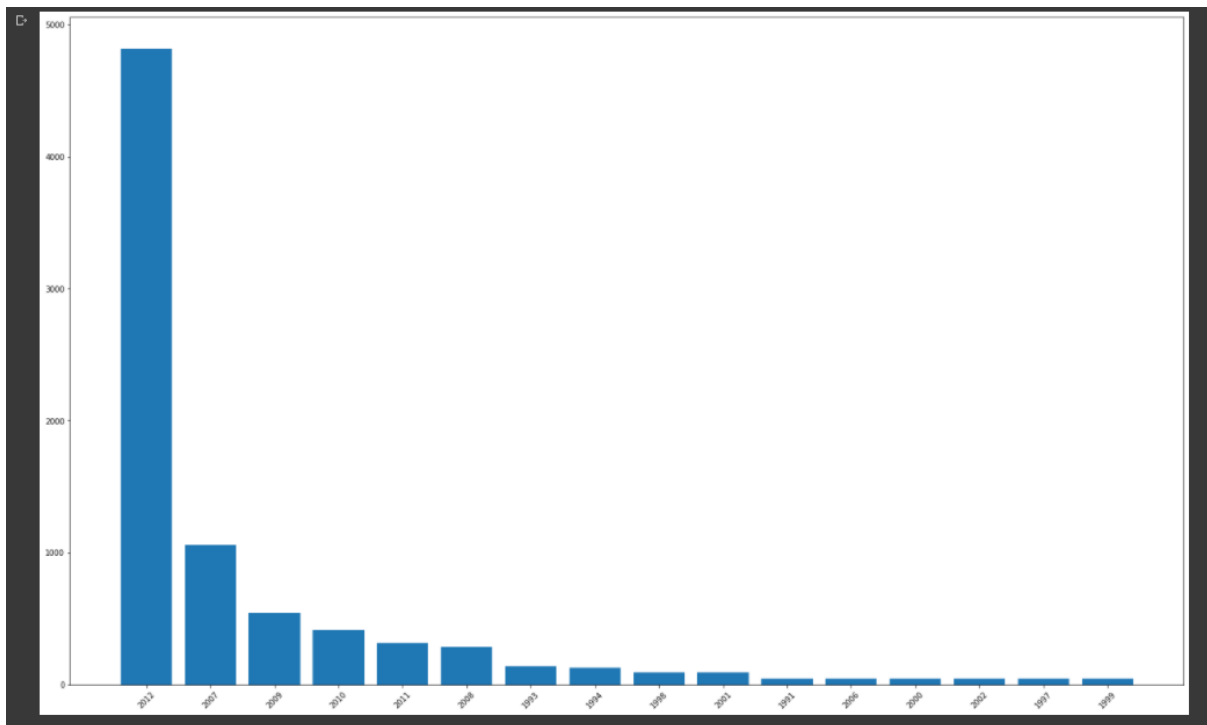
Class having maximum number of images in test dataset

Below mentioned picture shows 5 classes which are having more number of images in the Test dataset.

carName	count
GMC Savana Van 2012	68
Chrysler 300 SRT-8 2010	48
Mercedes-Benz 300-Class Convertible 1993	48
Mitsubishi Lancer Sedan 2012	47
Audi S6 Sedan 2011	46

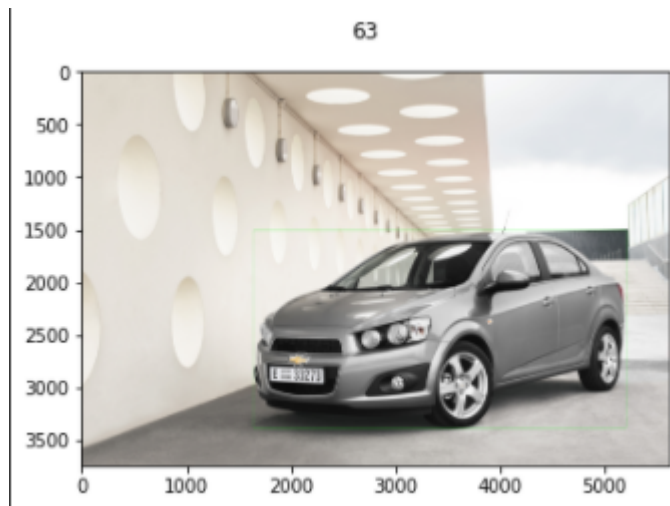
Number of car images based on Year

Below mentioned picture depicts the number of car images based on car model year. There are more images of cars which are of model 2012 and very less images belonging to model 1996.




Class distribution

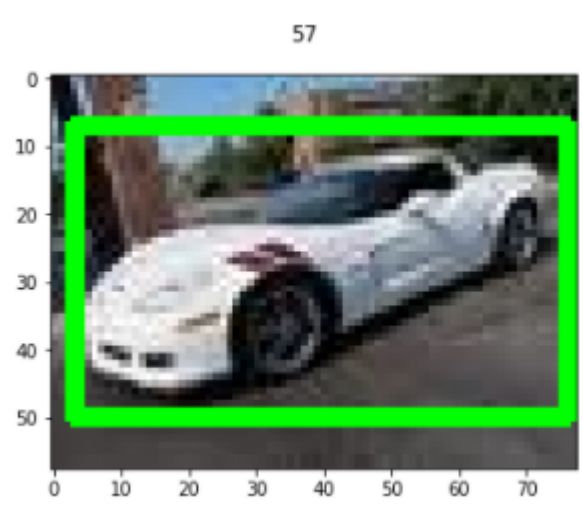
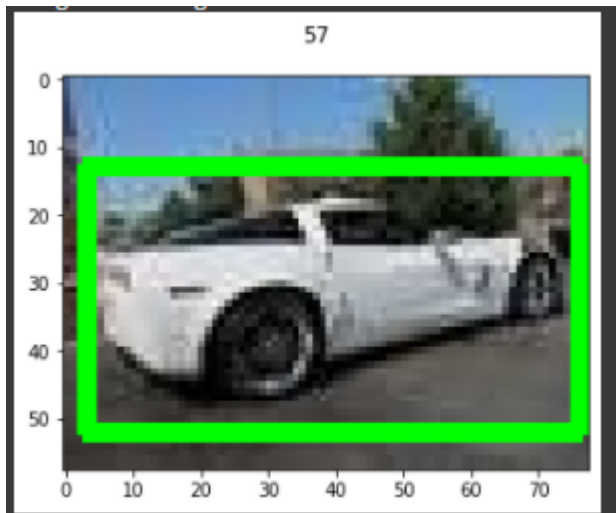
Almost all classes of cars images have an equal number of images which is of count around 40. There is a class named "GMC savana van 2012" which has 60 images and "Hyundai Accent sedan 2012" which has around 25 images. In below mentioned pictures we can view the class distribution.



Minimum Size of the image available in dataset

Below mentioned pictures show the details which are images which are having very less size.

	carName	imageName	Height	Width	
2543	Chevrolet Corvette Ron Fellows Edition Z06 2007	07469.jpg	58	78	
2558	Chevrolet Corvette Ron Fellows Edition Z06 2007	00097.jpg	58	78	



Checking bounding boxes on the image

Applying bounding boxes on random images to check if the annotations provided are matching with that of images. The images are decided to be resized to 224x224 and corresponding bounding boxes are modified based on ratio of height and width.

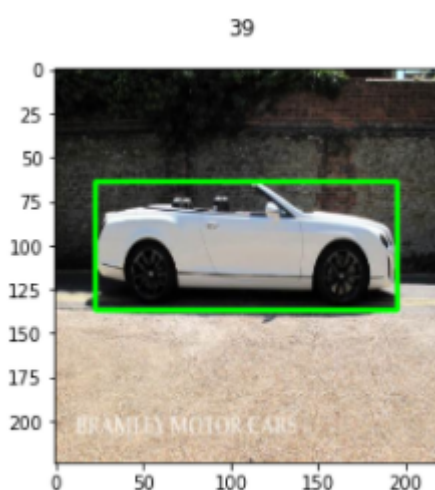
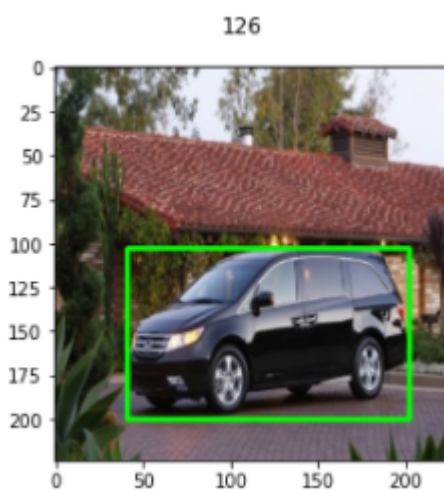


Image Pre-processing

For Preprocessing images, below mentioned simple 3 steps are followed.

1. Reading images from images folder
2. Reading annotation file
3. Extracting image height and width
4. Merging image annotation dataset with data produced in above 2 steps.

Creating dataset from images folder

The images subdirectory contains all images in our dataset, with a corresponding subdirectory for the name of the label. We start with loading the Car Name and Class Name into a pandas dictionary object.

Loading Annotations file in a pandas Dataframe object. Each row in Annotations file consists of consists of six elements:

1. Image Filename
2. Starting x-coordinate
3. Starting y-coordinate
4. Ending x-coordinate
5. Ending y-coordinate
6. Class label number

Looping over our CSV annotation files, we grab all rows in the file and proceed to loop over each of them.

Inside our loop, we unpack the comma-delimited row giving us our filename, (x, y)-coordinates, and class label for the particular line in the CSV. We lagain oop through the annotations dataframe and update new columns for Class Name and build Image path name. Using the imagePath derived from our config, class label, and filename,we load the image and extract its spatial dimensions. We then scale the bounding box coordinates relative to the original image's dimensions to the range [0, 1] — this scaling serves as our preprocessing for the bounding box data.

Finally we load the image from disk in Keras/TensorFlow format and preprocess it with a resizing step which forces the image to 224×224 pixels for input for the model. Next step is to One-hot encode our labels using LabelBinarizer.

SECTION 3: MODEL DETAILS

Deciding Models

The problem statement states that it is a Automotive. Surveillance problem and the context states that computer vision can be used to automate supervision and triggering events for images of interest.

By understanding these statements, we can conclude that the problem can be solved by using deep learning techniques. In Deep learning techniques, we can look into particular sections of CNNs. CNN are complicated feed forward neural networks used in machine learning. Because of its great accuracy, CNNs are employed for image classification, image localization , image detection , etc. The CNN uses a hierarchical model that builds a network, similar to a funnel, and then outputs a fully-connected layer in which all neurons are connected to each other and the output is processed. The benefit of using CNNs is their ability to develop an internal representation of an image by looking at only a subset of pixels in the images.

We cannot use a Dense neural network for computer vision tasks in deep learning. The fundamental difference between the Convolutional and Dense layers is that the Convolutional layer requires fewer parameters because the input values are forced to share the parameters. The Dense Layer employs a linear operation, which means that the function generates each output based on each input. An output of the convolution layers is formed by just a small size of inputs which depends on the filter's size and the weights are shared for all the pixels

For this problem statement we have decided to use transfer learning and use a pre-built model in tensorflow. Few layers in pre-built models can be trained to get good accuracy and best prediction for the bounding box. Transfer learning is adaptable, allowing pre-trained models to be used directly as feature extraction preprocessing or integrated into completely new models. We have evaluated a few pre-trained models - MobileNet, ResNet50 and efficient net as part of the experiment. Among these evaluations we have got the best result for an efficient net - efficientnet-b5.

Model Building

MobileNet

MobileNets are built on a simplified design that builds light weight deep neural networks using depth-wise separable convolutions. Two simple global hyper-parameters are introduced that efficiently trade off latency and accuracy. These hyper-parameters help the model builder to select the appropriate model size for their application based on the problem constraints. We are using a specific version of mobile net model MobileNetV2. MobileNetV2 is very similar to the original MobileNet, except that it uses inverted residual blocks with bottlenecking features. It has a drastically lower parameter count than the original MobileNet. MobileNets support any input size greater than 32 x 32, with larger image sizes offering better performance.

The network is a fairly simple network with less number of weights to be trained. We are retraining the model right from input layer and we have added dense layer and dropout layer along with batch normalization as final layer for classification and regression (calculation of bounding box).

We are using categorical_crossentropy for classification and mse for regression. We calculate the overall loss of the model by adding regression loss and classification loss. For calculating accuracy of the bounding box on the images, we have defined a function to

calculate IOU. This Intersection over Union is an evaluation metric used to measure the accuracy of an object detector on a particular dataset.

Below mentioned are the weight which are to be learnt for mobile net model

Total params: 4,988,104

Trainable params: 4,953,352

Non-trainable params: 34,752

Resnet50

ResNet50 is a ResNet variation of 48 Convolution layers, 1 MaxPool layer, and 1 Average Pool layer. There are 3.8×10^9 floating point operations in it. It's a popular ResNet model. ResNet is a technique for dealing with the vanishing gradient problem in deep CNNs. They work by bypassing some layers, believing that very deep networks should not have a higher training error than shallower networks.

Here we have retrained the entire model, this model has 28 Million trainable parameters. The Last layer of the model has GlobalAveragePooling2D, 2 Dense layer, 1 dropout layer and a Batch normalization layer. For classification we have used softmax activation function with 196 classes and for regression we have used sigmoid activation function for 4 coordinates of the bounding box.

We are using categorical_crossentropy for classification and mse for regression. We calculate the overall loss of the model by adding regression loss and classification loss. For calculating accuracy of the bounding box on the images, we have defined a function to calculate IOU. This Intersection over Union is an evaluation metric used to measure the accuracy of an object detector on a particular dataset.

Below mentioned are the weight which are to be learnt for mobile net model

Total params: 28,937,800

Trainable params: 28,883,656

Non-trainable params: 54,144

Efficientnet-b5

Efficientnet-b5 model with ImageNet weights is used for developing network for classification and regression tasks for the given problem statement. The efficientnet-b5 model is one of the EfficientNet models designed to perform image classification. All the EfficientNet models have been pre trained on the ImageNet image database.

Efficientnet-b5 has 576 total layers, from layer number 257 we have made it trainable. This model has 28 Million trainable parameters. The Last layer of the model has GlobalAveragePooling2D, 1 Dense layer and a Batch normalization layer. For classification

we have used softmax activation function with 196 classes and for regression we have used sigmoid activation function for 4 coordinates of the bounding box.

We are using categorical_crossentropy for classification and mse for regression. We calculate the overall loss of the model by adding regression loss and classification loss. For calculating accuracy of the bounding box on the images, we have defined a function to calculate IOU. This Intersection over Union is an evaluation metric used to measure the accuracy of an object detector on a particular dataset.

Number of weights after final model building is as mentioned below.

Total params: 33,127,871
Trainable params: 31,496,968
Non-trainable params: 1,630,903

Efficientnet-b7

Efficientnet-b7 model with ImageNet weights is used for developing network for classification and regression tasks for the given problem statement. The efficientnet-b7 model is one of the EfficientNet models designed to perform image classification. All the EfficientNet models have been pre trained on the ImageNet image database.

Efficientnet-b7 has 813 total layers, from layer number 351 we have made it trainable. This model has 64 Million trainable parameters. The Last layer of the model has GlobalAveragePooling2D, 1 Dense layer and a Batch normalization layer. For classification we have used softmax activation function with 196 classes and for regression we have used sigmoid activation function for 4 coordinates of the bounding box.

We are using categorical_crossentropy for classification and mse for regression. We calculate the overall loss of the model by adding regression loss and classification loss. For calculating accuracy of the bounding box on the images, we have defined a function to calculate IOU. This Intersection over Union is an evaluation metric used to measure the accuracy of an object detector on a particular dataset.

Number of weights after final model building is as mentioned below.

Total params: 71,176,287
Trainable params: 67,594,112
Non-trainable params: 3,582,175

Conclusion

Here we have chosen EfficientNet-B7 and since this is an interim submission, we are planning to continue our experiment with other networks and methodologies. We are trying to build YOLO and we are also using the TFOD framework to check which would give the best result. We also started with efficientDet. For final submission we will compare all the models and get the best model deployed and produce a result in a nice user interface.

SECTION 4: RESULTS AND DISCUSSION

Model performance

For this object localization problem we have tried MobileNet, Resnet50, EfficientNet-B5 and EfficientNet-B7. Among these three models we have found the best performing model is EfficientNet-B5. In this section we have mentioned the observed test accuracy and few test samples.

MobileNet being a streamlined architecture, has shown good accuracy for train and validation set of data but performs poorly on unseen test dataset. Test results are mentioned in the table with the title “Test Result for different model”. Classification report is available in Tables and figure section in table with title “Classification report for MobileNet”

ResNet50 but performs poorly on unseen test dataset. Test results are mentioned in the table with the title “Test Result for different model”. Classification report is available in Tables and figure section in table with title “Classification report for ResNet”

EfficientNet-B5 performs well on unseen test dataset. Test results are mentioned in the table with the title “Test Result for different model”. Classification report is available in Tables and figure section in table with title “Classification report for EfficientNet-B5”

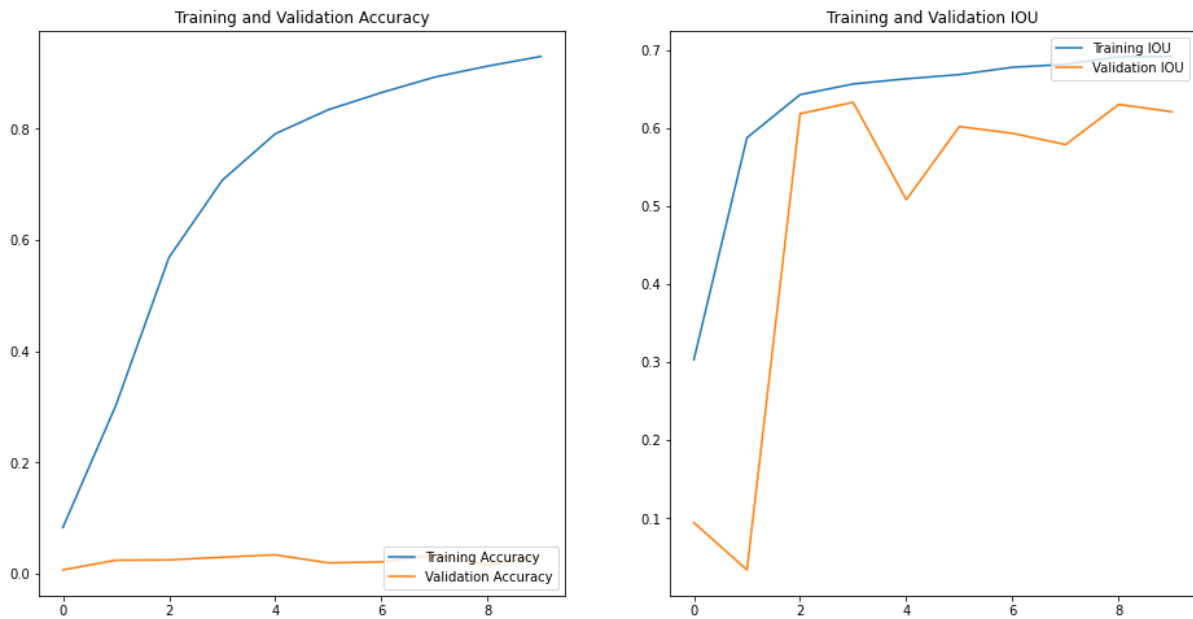
EfficientNet-B7 performs well on unseen test dataset. Test results are mentioned in the table with the title “Test Result for different model”. Classification report is available in Tables and figure section in table with title “Classification report for EfficientNet-B7”

Model	loss	Class_op_loss	reg_op_loss	class_op_accuracy	reg_op_loU
MobileNet	1.143170595	1.140172958	0.002998107346	0.7411249876	0.8120642304
ResNet50	4.882508278	4.872550488	0.009955173358	0.06724999845	0.7253609896
EfficientNet-B5	1.271269798	1.268125296	0.003145831171	0.7512500286	0.8126088381
EfficientNet-B7	1.153328776	1.150439143	0.002889547963	0.7966250181	0.8201269507

Table 1.1 : Test Result for different model

Mobile Net Classification accuracy and IOU

The mobile net is trained in 2 phases, 1st phase with 10 epochs and batch size as 64 and in 2nd phase 15 more epochs with batch size as 16.

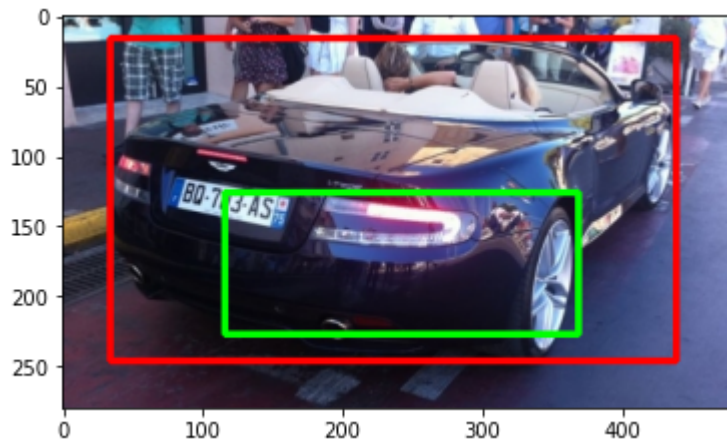


Above figure shows the training vs validation accuracy and Training vs validation IOU in first phase.

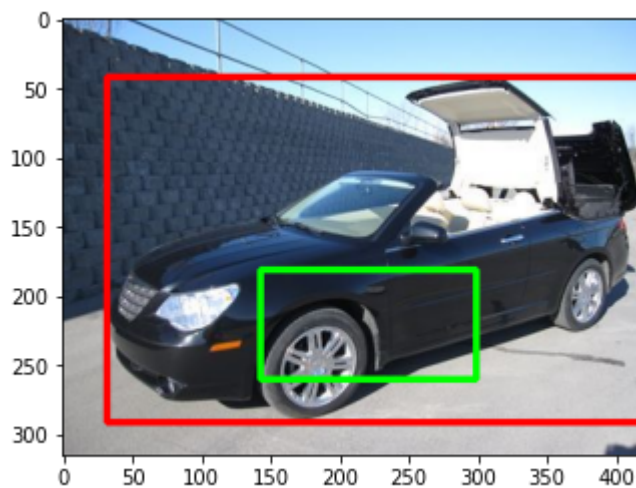


Above figure shows the training vs validation accuracy and Training vs validation IOU in the second phase.

As we can observe the accuracy for classification is very low in validation and the model is an overfitting model with a large gap between training vs validation accuracy. Although the model IOU is fine as per graph, the final output on the data is not acceptable. Few samples of the output of the MobileNet model are mentioned below.



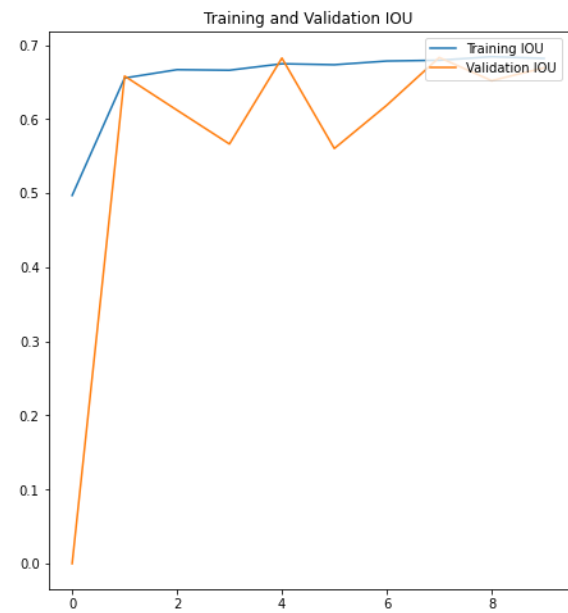
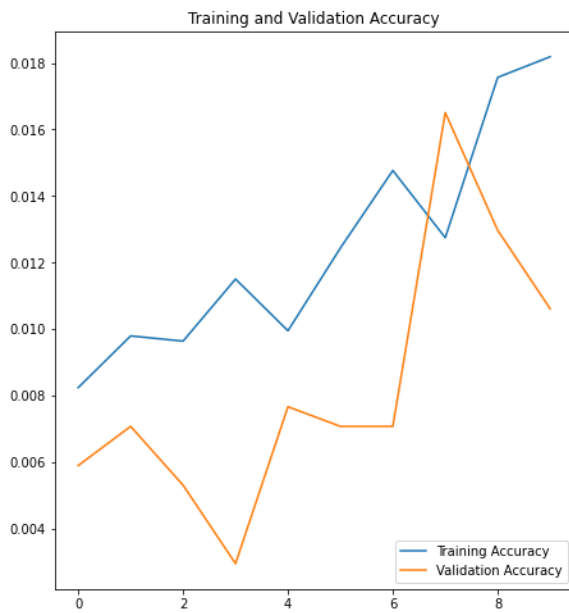
Real Label : Aston Martin Virage Convertible 2012
 Predicted Label: Hyundai Veracruz SUV 2012



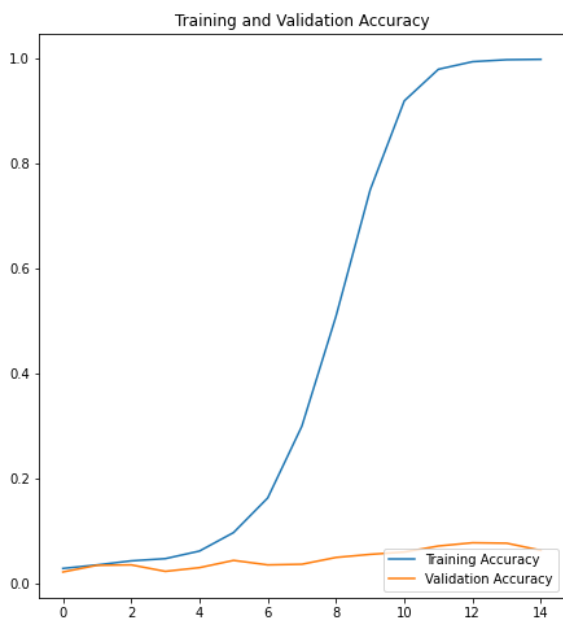
Real Label : Chrysler Sebring Convertible 2010
 Predicted Label: Hyundai Veracruz SUV 2012

Res Net Classification accuracy and IOU

The Resnet50 is trained in 2 phases, 1st phase with 10 epochs and batch size as 64 and in 2nd phase 10 more epochs with batch size as 16.

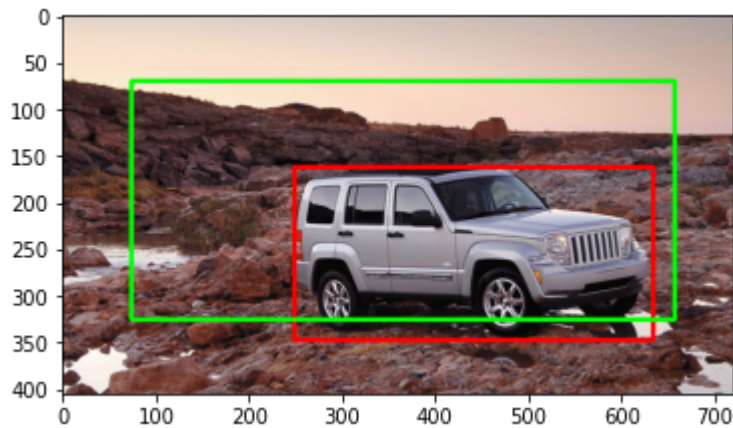


Above figure shows the training vs validation accuracy and Training vs validation IOU in first phase.



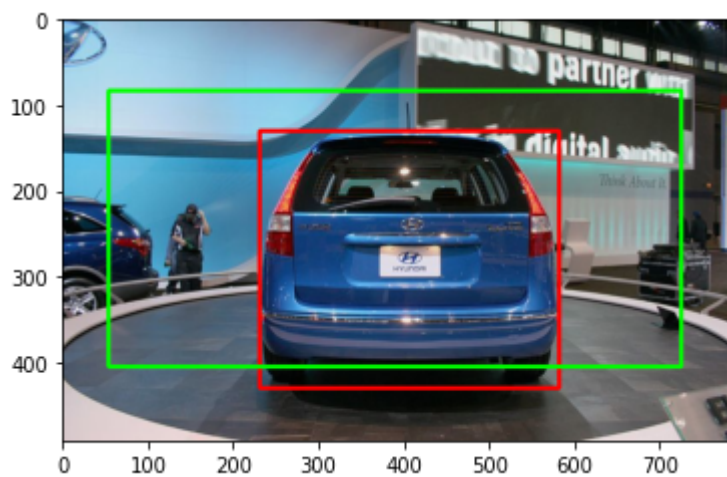
Above figure shows the training vs validation accuracy and Training vs validation IOU in the second phase.

As we can observe the accuracy for classification is very low in validation and the model is an overfitting model with a large gap between training vs validation accuracy. The IOU of the model is also not acceptable. Few samples of the output of the MobileNet model are mentioned below.



Real Label : Jeep Liberty SUV 2012

Predicted Label: Dodge Ram Pickup 3500 Crew Cab 2010



Real Label : Hyundai Elantra Touring Hatchback 2012

Predicted Label: Chevrolet Avalanche Crew Cab 2012

Efficient Net B5 Classification accuracy and IOU

The EfficientNet-B5 is trained in 2 phases, 1st phase with 10 epochs and batch size as 64 and in 2nd phase 10 more epochs with batch size as 16.

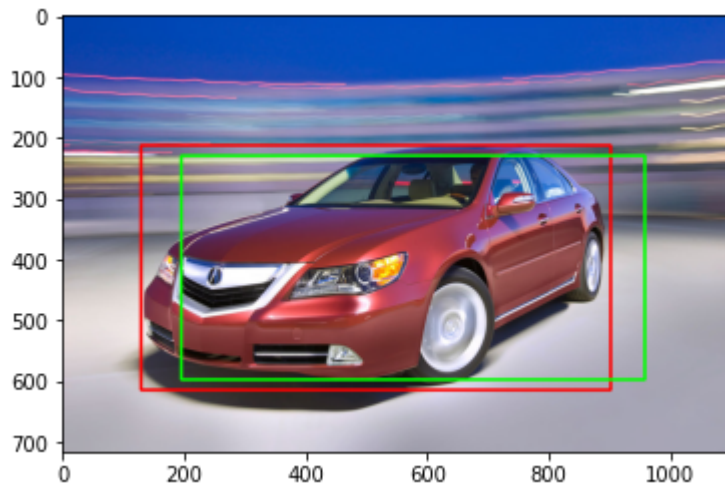


Above figure shows the training vs validation accuracy and Training vs validation IOU in the first phase.



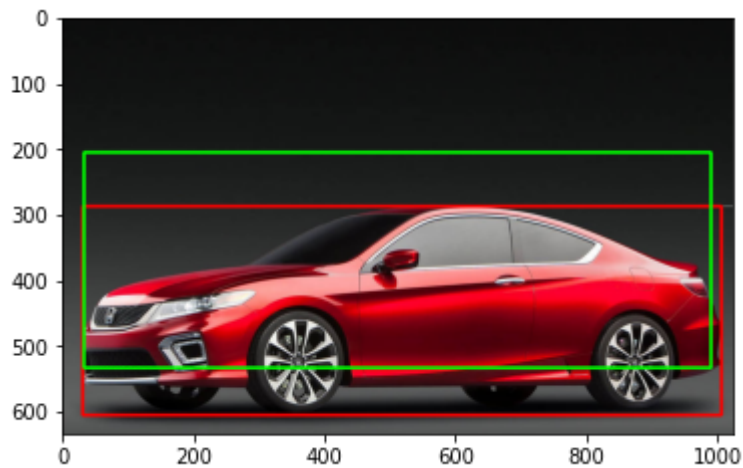
Above figure shows the training vs validation accuracy and Training vs validation IOU in the second phase.

The training vs validation accuracy in the first phase is having a gap between them but with the second phase the validation accuracy has improved. Although the observed gap is more, for a check on a few thousand sample data, the classification seems to be acceptable. The IOU of the model has performed pretty well and compared to resnet50 and MobileNet, the bounding boxes on the sample data has shown improvement. Below mentioned are a few samples of the dataset.



Real Label : Acura RL Sedan 2012

Predicted Label: Acura RL Sedan 2012

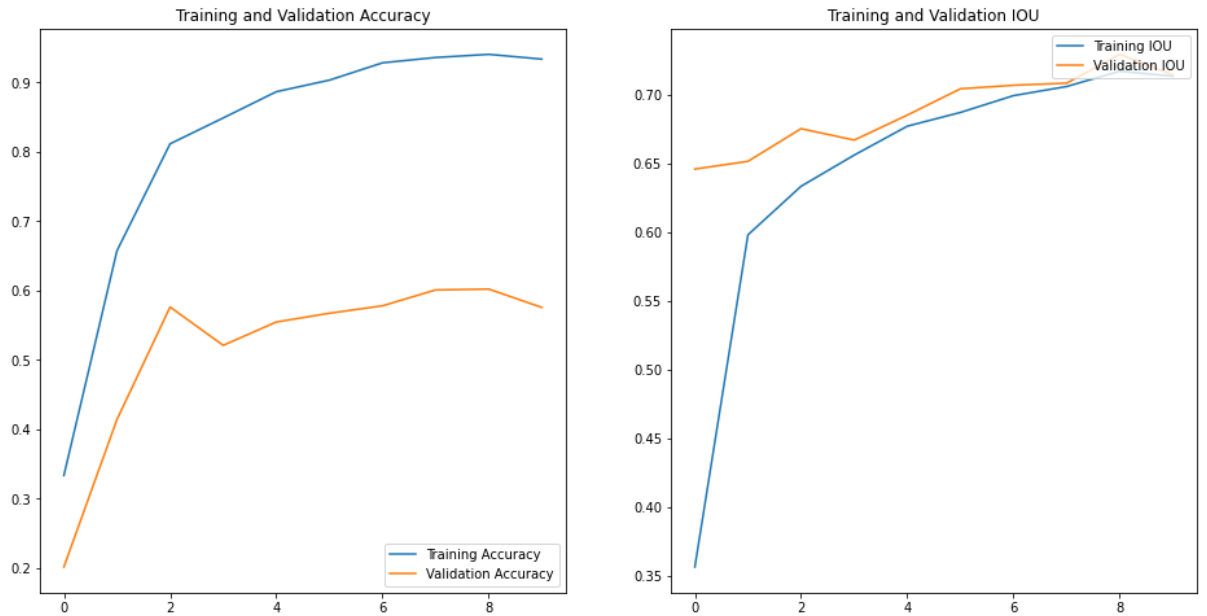


Real Label : Honda Accord Coupe 2012

Predicted Label: Honda Accord Coupe 2012

Efficient Net B7 Classification accuracy and IOU

The EfficientNet-B7 is trained in 2 phases, 1st phase with 10 epochs and batch size as 64 and in 2nd phase 15 more epochs with batch size as 16.



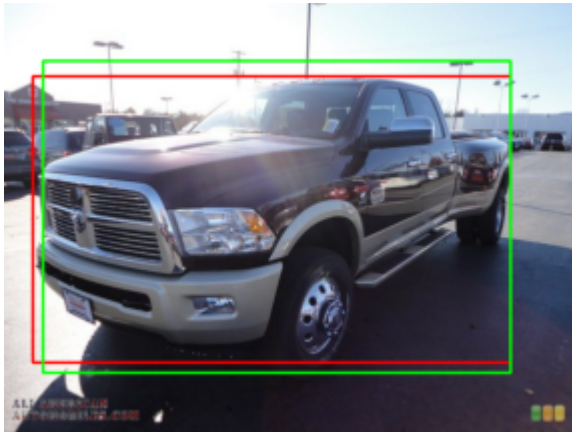
Above figure shows the training vs validation accuracy and Training vs validation IOU in the first phase.



Above figure shows the training vs validation accuracy and Training vs validation IOU in the second phase.

The training vs validation accuracy in the first phase is having a gap between them but with the second phase the validation accuracy has improved. Although the observed gap is more, for a check on a few thousand sample data, the classification seems to be acceptable. The IOU of the model has performed pretty well and compared to resnet50 and MobileNet, the

bounding boxes on the sample data has shown improvement. Below mentioned are a few samples of the dataset.



Real Label : Dodge Ram Pickup 3500 Crew Cab 2010
Predicted Label: Dodge Ram Pickup 3500 Crew Cab 2010



Real Label : BMW ActiveHybrid 5 Sedan 2012
Predicted Label: BMW ActiveHybrid 5 Sedan 2012

Based on the performance, the EfficientNet-B7 model is finally chosen, which is having the best performance among all the ones we have seen so far.

Approaches for Improve performance of model

Data Augmentation

One of the ways of improving the model performance is to train the model on more images. The training of deep learning models usually necessitates a large amount of data. In general, the more data there is, the better the model will perform. The issue with a paucity of data is that our deep learning model may not be able to learn the pattern from the data, and so may result in poor performance on test data.

Instead of collecting more data, augmentation techniques can be applied to generate as much data as required. Some of the commonly used augmentation techniques are rotation, shear, flip, etc. While applying data augmentation techniques for the given problem statement, we have to modify the bounding box coordinates as well. For this purpose, we can make use of `imgaug` or `chitra` libraries which are readily available and apply few inbuilt functions on images for data augmentation.

One of the augmenters which is available in the library is `Affine`. Affine transformations involve Translation (“move” image on the x-/y-axis), Rotation, Scaling (“zoom” in/out), Shear (move one side of the image, turning a square into a trapezoid). This Augmenter will affect bounding boxes and hence we need to use `BoundingBoxesOnImage` function on the bounding box coordinates.

Horizontal flips, Resize and change brightness can also be applied on the images and these functions can be wrapped in a function which can then be applied using a batch generator for the images.

Transfer learning

Unfreezing a portion of a model and retraining it with a very low learning rate on the new data would give significant improvement in model accuracy. Since the dataset which is provided to us has 8144 images and data similarity is quite low, freezing initial layers of the pretrained model and re-train just the remaining layers will help in accuracy improvement.

Here it is recommended to keep the learning rate very low since the layers are unfrozen and model weights are trainable. Because the training will be done on a larger model it's also crucial to utilise a very modest learning rate at this stage. There are substantial weight changes happening here and there is always a danger of overfitting. So incremental readjustment of the pre-trained weights are crucial.

Last layer Classification and regression

If the model is overfitting for given data, dropout layer can be introduced between last dense layers which will help in reduction of overfitting. Dropout is a training strategy in which randomly selected neurons are rejected. They are “dropped-out” randomly. This means that on the forward pass, their contribution to the activation of downstream neurons is removed temporally, and on the backward pass, any weight updates are not applied to the neuron.

Using Batch normalization helps in reduction of general errors. Batch normalisation is a technique for standardising network inputs that can be applied to either the activations of a previous layer or the inputs themselves. Batch normalisation reduces generalisation error by speeding up training (in some situations by halving or bettering the epochs) and providing some regularisation.

CLASSIFICATION REPORTS

MobileNet

Classification report

Below mentioned table classification report for MobileNet model. Overall Accuracy is low for this model. The problem observed for MobileNet is that the network is a small network and not suitable for this use case, the number of weights which are to be learnt is very less leading to misclassification and bounding boxes which are overlaid by model on the image are misaligned. The number of samples used for producing reports is 8041

Model	precision	recall	f1-score	support
Acura Integra Type R 2001	0.19	0.09	0.12	44
Acura RL Sedan 2012	0	0	0	44
Acura TL Sedan 2012	0	0	0	32
Acura TL Type-S 2008	0	0	0	43
Acura TSX Sedan 2012	0	0	0	42
Acura ZDX Hatchback 2012	0	0	0	40
AM General Hummer SUV 2000	0	0	0	39
Aston Martin V8 Vantage Convertible 2012	0	0	0	45
Aston Martin V8 Vantage Coupe 2012	0	0	0	41
Aston Martin Virage Convertible 2012	0	0	0	33
Audi 100 Sedan 1994	0	0	0	38
Audi 100 Wagon 1994	0	0	0	40
Aston Martin Virage Coupe 2012	0	0	0	42
Audi A5 Coupe 2012	0	0	0	41
Audi S4 Sedan 2007	0.09	0.02	0.04	43
Audi RS 4 Convertible 2008	0	0	0	36
Audi R8 Coupe 2012	0	0	0	45
Audi S5 Convertible 2012	0	0	0	39
Audi S4 Sedan 2012	0	0	0	42
Audi S5 Coupe 2012	0	0	0	42
Audi TT Hatchback 2011	0	0	0	46
Audi TT RS Coupe 2012	0	0	0	40
Audi TTS Coupe 2012	0	0	0	39

Bentley Continental Flying Spur Sedan 2007	0	0	0	42
Audi V8 Sedan 1994	0	0	0	43
Bentley Arnage Sedan 2009	0	0	0	35
Audi S6 Sedan 2011	0	0	0	41
Bentley Continental GT Coupe 2007	0	0	0	42
Bentley Continental Supersports Conv. Convertible 2012	0.02	0.05	0.03	41
Bentley Continental GT Coupe 2012	0	0	0	44
BMW 1 Series Convertible 2012	0	0	0	34
BMW 1 Series Coupe 2012	0	0	0	44
Bentley Mulsanne Sedan 2011	0	0	0	41
BMW 3 Series Sedan 2012	0	0	0	41
BMW 3 Series Wagon 2012	0	0	0	38
BMW 6 Series Convertible 2007	0	0	0	41
BMW M3 Coupe 2012	0	0	0	42
BMW M5 Sedan 2010	0	0	0	40
BMW M6 Convertible 2010	0	0	0	39
BMW ActiveHybrid 5 Sedan 2012	0.02	0.05	0.02	44
BMW X5 SUV 2007	0	0	0	46
BMW X3 SUV 2012	0	0	0	34
BMW X6 SUV 2012	0	0	0	36
Bugatti Veyron 16.4 Coupe 2009	0	0	0	35
Bugatti Veyron 16.4 Convertible 2009	0	0	0	32
BMW Z4 Convertible 2012	0.11	0.02	0.04	43
Buick Enclave SUV 2012	0	0	0	42
Buick Regal GS 2012	0	0	0	42
Buick Rainier SUV 2007	0.5	0.03	0.05	35
Cadillac Escalade EXT Crew Cab 2007	0.04	0.08	0.05	37
Buick Verano Sedan 2012	0	0	0	43
Cadillac CTS-V Sedan 2012	0	0	0	44
Cadillac SRX SUV 2012	0	0	0	41
Chevrolet Camaro Convertible 2012	0	0	0	45
Chevrolet Cobalt SS 2010	0	0	0	44
Chevrolet Avalanche Crew Cab 2012	0	0	0	41
Chevrolet Corvette Ron Fellows Edition Z06 2007	0	0	0	39
Chevrolet Corvette ZR1 2012	0	0	0	37
Chevrolet Corvette Convertible 2012	0	0	0	46

Chevrolet Express Cargo Van 2007	0	0	0	29
Chevrolet HHR SS 2010	0	0	0	35
Chevrolet Express Van 2007	0	0	0	36
Chevrolet Malibu Hybrid Sedan 2010	0.02	0.02	0.02	43
Chevrolet Malibu Sedan 2007	0	0	0	38
Chevrolet Monte Carlo Coupe 2007	0	0	0	44
Chevrolet Impala Sedan 2007	0	0	0	45
Chevrolet Silverado 1500 Classic Extended Cab 2007	0	0	0	42
Chevrolet Silverado 1500 Hybrid Crew Cab 2012	0	0	0	43
Chevrolet Silverado 1500 Extended Cab 2012	0	0	0	40
Chevrolet Silverado 2500HD Regular Cab 2012	0	0	0	44
Chevrolet Silverado 1500 Regular Cab 2012	0	0	0	38
Chevrolet Sonic Sedan 2012	1	0.02	0.04	44
Chevrolet TrailBlazer SS 2009	0	0	0	37
Chevrolet Tahoe Hybrid SUV 2012	0	0	0	40
Chevrolet Traverse SUV 2012	0	0	0	44
Chrysler PT Cruiser Convertible 2008	0.12	0.02	0.04	48
Chrysler Aspen SUV 2009	0	0	0	43
Chrysler Crossfire Convertible 2008	0	0	0	43
Chrysler 300 SRT-8 2010	0	0	0	45
Daewoo Nubira Wagon 2002	0	0	0	40
Chrysler Sebring Convertible 2010	0	0	0	37
Chrysler Town and Country Minivan 2012	0	0	0	45
Dodge Caliber Wagon 2007	0	0	0	42
Dodge Caravan Minivan 1997	0	0	0	40
Dodge Caliber Wagon 2012	0	0	0	43
Dodge Challenger SRT8 2011	0	0	0	39
Dodge Charger SRT-8 2009	0	0	0	42
Dodge Charger Sedan 2012	0	0	0	41
Dodge Durango SUV 2007	0	0	0	38
Dodge Durango SUV 2012	0	0	0	41
Dodge Dakota Crew Cab 2010	0	0	0	45
Dodge Dakota Club Cab 2007	0.2	0.02	0.04	43
Dodge Journey SUV 2012	0	0	0	44
Dodge Ram Pickup 3500 Crew Cab 2010	0	0	0	40

Dodge Magnum Wagon 2008	0	0	0	42
Dodge Sprinter Cargo Van 2009	0	0	0	44
Dodge Ram Pickup 3500 Quad Cab 2009	0	0	0	39
Eagle Talon Hatchback 1998	0	0	0	46
Ferrari 458 Italia Convertible 2012	0	0	0	27
Ford F-150 Regular Cab 2007	0	0	0	33
Ferrari 458 Italia Coupe 2012	0	0	0	39
Ford Edge SUV 2012	0	0	0	42
Ferrari California Convertible 2012	0	0	0	39
FIAT 500 Convertible 2012	0	0	0	42
Ford E-Series Wagon Van 2012	0	0	0	43
FIAT 500 Abarth 2012	0	0	0	37
Ferrari FF Coupe 2012	0	0	0	43
Fisker Karma Sedan 2012	0	0	0	44
Ford Expedition EL SUV 2009	0	0	0	45
Ford Focus Sedan 2007	0	0	0	42
Ford F-450 Super Duty Crew Cab 2012	0	0	0	41
Ford Ranger SuperCab 2011	0	0	0	42
Ford F-150 Regular Cab 2012	0	0	0	45
Ford Freestar Minivan 2007	0	0	0	44
Geo Metro Convertible 1993	0.07	0.27	0.11	45
GMC Acadia SUV 2012	0	0	0	44
Ford Fiesta Sedan 2012	0	0	0	42
Ford Mustang Convertible 2007	0	0	0	44
Ford GT Coupe 2006	0	0	0	40
GMC Terrain SUV 2012	0	0	0	68
GMC Savana Van 2012	0	0	0	41
GMC Canyon Extended Cab 2012	0	0	0	42
Honda Odyssey Minivan 2007	0	0	0	44
GMC Yukon Hybrid SUV 2012	0	0	0	43
Honda Odyssey Minivan 2012	0	0	0	39
Honda Accord Sedan 2012	0	0	0	39
HUMMER H2 SUT Crew Cab 2009	0	0	0	38
HUMMER H3T Crew Cab 2010	0	0	0	41
Honda Accord Coupe 2012	0	0	0	42
Hyundai Elantra Touring Hatchback 2012	0	0	0	24
Hyundai Santa Fe SUV 2012	0	0	0	42

Hyundai Tucson SUV 2012	0	0	0	42
Hyundai Sonata Hybrid Sedan 2012	0.1	0.02	0.04	42
Hyundai Veloster Hatchback 2012	0	0	0	43
Hyundai Azera Sedan 2012	0	0	0	42
Hyundai Genesis Sedan 2012	0	0	0	33
Hyundai Elantra Sedan 2007	0	0	0	39
Hyundai Sonata Sedan 2012	0	0	0	43
Hyundai Accent Sedan 2012	0.17	0.02	0.04	41
Infiniti QX56 SUV 2011	0.01	0.33	0.01	42
Jeep Wrangler SUV 2012	0	0	0	34
Jeep Patriot SUV 2012	0	0	0	32
Infiniti G Coupe IPL 2012	0	0	0	40
Jeep Compass SUV 2012	0	0	0	46
Jeep Grand Cherokee SUV 2012	0	0	0	42
Jaguar XK XKR 2012	0	0	0	45
Hyundai Veracruz SUV 2012	0	0	0	44
Jeep Liberty SUV 2012	0	0	0	44
Isuzu Ascender SUV 2008	0	0	0	43
Lincoln Town Car Sedan 2011	0.01	0.09	0.02	43
Land Rover Range Rover SUV 2012	0	0	0	44
Lamborghini Reventon Coupe 2008	0.01	0.14	0.01	35
Land Rover LR2 SUV 2012	0	0	0	36
Lamborghini Gallardo LP 570-4 Superleggera 2012	0	0	0	42
Mazda Tribute SUV 2011	0	0	0	42
Lamborghini Diablo Coupe 2001	0	0	0	39
Lamborghini Aventador Coupe 2012	0	0	0	36
Maybach Landaulet Convertible 2012	0.01	0.59	0.01	29
McLaren MP4-12C Coupe 2012	0	0	0	36
Mercedes-Benz E-Class Sedan 2012	0.01	0.02	0.02	44
MINI Cooper Roadster Convertible 2012	0	0	0	48
Nissan Juke Hatchback 2012	0	0	0	45
Mercedes-Benz S-Class Sedan 2012	0	0	0	43
Nissan 240SX Coupe 1998	0	0	0	44
Mitsubishi Lancer Sedan 2012	0	0	0	36
Mercedes-Benz Sprinter Van 2012	0	0	0	41
Mercedes-Benz C-Class Sedan 2012	0	0	0	47
Mercedes-Benz 300-Class Convertible 1993	0	0	0	46

Mercedes-Benz SL-Class Coupe 2009	0	0	0	44
Rolls-Royce Ghost Sedan 2012	0	0	0	42
Nissan Leaf Hatchback 2012	0	0	0	38
Nissan NV Passenger Van 2012	0	0	0	44
Rolls-Royce Phantom Sedan 2012	0	0	0	43
Rolls-Royce Phantom Drophead Coupe Convertible 2012	0	0	0	41
Porsche Panamera Sedan 2012	0.03	0.16	0.06	38
Scion xD Hatchback 2012	0	0	0	30
Ram C-V Cargo Van Minivan 2012	0	0	0	44
Plymouth Neon Coupe 1999	0	0	0	41
smart fortwo Convertible 2012	0	0	0	45
Toyota Camry Sedan 2012	0	0	0	42
Toyota Corolla Sedan 2012	0	0	0	38
Tesla Model S Sedan 2012	0	0	0	46
Spyker C8 Convertible 2009	0.05	0.12	0.07	42
Spyker C8 Coupe 2009	0.01	0.05	0.01	40
Suzuki SX4 Sedan 2012	0	0	0	38
Suzuki Kizashi Sedan 2012	0	0	0	40
Toyota 4Runner SUV 2012	0	0	0	43
Suzuki SX4 Hatchback 2012	0	0	0	43
Suzuki Aerio Sedan 2007	0	0	0	38
Volvo XC90 SUV 2007	0	0	0	42
Volvo C30 Hatchback 2012	0	0	0	46
Volkswagen Beetle Hatchback 2012	0	0	0	43
Volvo 240 Sedan 1993	0	0	0	45
Volkswagen Golf Hatchback 2012	0	0	0	41
Volkswagen Golf Hatchback 1991	0	0	0	43
Toyota Sequoia SUV 2012	0	0	0	40
accuracy			0.01	8041
macro avg	0.01	0.01	0	8041
weighted avg	0.01	0.01	0	8041

Table 5.1: Classification report for MobileNet

Sample outputs of MobileNet are mentioned below, the results are not satisfactory.

ResNet50

Below mentioned table classification report is for Resnet50 model. Overall Accuracy is low for this model. The problem observed for ResNet50 is that the network doesn't learn well. ResNet follows the conventional approach of scaling the dimensions arbitrarily and by adding up more and more layers. As observed, ResNet is not suitable for this use case. There are misclassifications observed and bounding boxes which are overlaid by model on the image are misaligned. The number of samples used for producing reports is 8041

Classification report

	precision	recall	f1-score	support
Acura Integra Type R 2001	0	0	0	44
Acura RL Sedan 2012	0	0	0	44
Acura TL Sedan 2012	0	0	0	32
Acura TL Type-S 2008	0	0	0	43
Acura TSX Sedan 2012	0.03	0.02	0.03	42
Acura ZDX Hatchback 2012	0	0	0	40
AM General Hummer SUV 2000	0	0	0	39
Aston Martin V8 Vantage Convertible 2012	0	0	0	45
Aston Martin V8 Vantage Coupe 2012	0	0	0	41
Aston Martin Virage Convertible 2012	0	0	0	33
Audi 100 Sedan 1994	0	0	0	38
Audi 100 Wagon 1994	0	0	0	40
Aston Martin Virage Coupe 2012	0.01	0.05	0.02	42
Audi A5 Coupe 2012	0	0	0	41
Audi S4 Sedan 2007	0	0	0	43
Audi RS 4 Convertible 2008	0	0	0	36
Audi R8 Coupe 2012	0	0	0	45
Audi S5 Convertible 2012	0	0	0	39
Audi S4 Sedan 2012	0	0	0	42
Audi S5 Coupe 2012	0	0	0	42
Audi TT Hatchback 2011	0	0	0	46
Audi TT RS Coupe 2012	0	0	0	40
Audi TTS Coupe 2012	0	0	0	39
Bentley Continental Flying Spur Sedan 2007	0	0	0	42
Audi V8 Sedan 1994	0.01	0.02	0.01	43
Bentley Arnage Sedan 2009	0	0	0	35
Audi S6 Sedan 2011	0	0	0	41

Bentley Continental GT Coupe 2007	0	0	0	42
Bentley Continental Supersports Conv. Convertible 2012	0	0	0	41
Bentley Continental GT Coupe 2012	0	0	0	44
BMW 1 Series Convertible 2012	0	0	0	34
BMW 1 Series Coupe 2012	0	0	0	44
Bentley Mulsanne Sedan 2011	0	0	0	41
BMW 3 Series Sedan 2012	0	0	0	41
BMW 3 Series Wagon 2012	0	0	0	38
BMW 6 Series Convertible 2007	0	0	0	41
BMW M3 Coupe 2012	0	0	0	42
BMW M5 Sedan 2010	0	0	0	40
BMW M6 Convertible 2010	0	0	0	39
BMW ActiveHybrid 5 Sedan 2012	0	0	0	44
BMW X5 SUV 2007	0	0	0	46
BMW X3 SUV 2012	0	0	0	34
BMW X6 SUV 2012	0	0	0	36
Bugatti Veyron 16.4 Coupe 2009	0	0	0	35
Bugatti Veyron 16.4 Convertible 2009	0	0	0	32
BMW Z4 Convertible 2012	0	0	0	43
Buick Enclave SUV 2012	0.02	0.02	0.02	42
Buick Regal GS 2012	0	0	0	42
Buick Rainier SUV 2007	0	0	0	35
Cadillac Escalade EXT Crew Cab 2007	0	0	0	37
Buick Verano Sedan 2012	0	0	0	43
Cadillac CTS-V Sedan 2012	0	0	0	44
Cadillac SRX SUV 2012	0	0	0	41
Chevrolet Camaro Convertible 2012	0.01	0.04	0.02	45
Chevrolet Cobalt SS 2010	0	0	0	44
Chevrolet Avalanche Crew Cab 2012	0	0	0	41
Chevrolet Corvette Ron Fellows Edition Z06 2007	0	0	0	39
Chevrolet Corvette ZR1 2012	0	0	0	37
Chevrolet Corvette Convertible 2012	0	0	0	46
Chevrolet Express Cargo Van 2007	0	0	0	29
Chevrolet HHR SS 2010	0	0	0	35
Chevrolet Express Van 2007	0	0	0	36
Chevrolet Malibu Hybrid Sedan 2010	0	0	0	43

Chevrolet Malibu Sedan 2007	0	0	0	38
Chevrolet Monte Carlo Coupe 2007	0.01	0.02	0.01	44
Chevrolet Impala Sedan 2007	0	0	0	45
Chevrolet Silverado 1500 Classic Extended Cab 2007	0	0	0	42
Chevrolet Silverado 1500 Hybrid Crew Cab 2012	0	0	0	43
Chevrolet Silverado 1500 Extended Cab 2012	0	0	0	40
Chevrolet Silverado 2500HD Regular Cab 2012	0	0	0	44
Chevrolet Silverado 1500 Regular Cab 2012	0	0	0	38
Chevrolet Sonic Sedan 2012	0	0	0	44
Chevrolet TrailBlazer SS 2009	0	0	0	37
Chevrolet Tahoe Hybrid SUV 2012	0	0	0	40
Chevrolet Traverse SUV 2012	0.01	0.05	0.02	44
Chrysler PT Cruiser Convertible 2008	0	0	0	48
Chrysler Aspen SUV 2009	0	0	0	43
Chrysler Crossfire Convertible 2008	0	0	0	43
Chrysler 300 SRT-8 2010	0	0	0	45
Daewoo Nubira Wagon 2002	0	0	0	40
Chrysler Sebring Convertible 2010	0.02	0.03	0.02	37
Chrysler Town and Country Minivan 2012	0.01	0.02	0.01	45
Dodge Caliber Wagon 2007	0	0	0	42
Dodge Caravan Minivan 1997	0	0	0	40
Dodge Caliber Wagon 2012	0.01	0.02	0.02	43
Dodge Challenger SRT8 2011	0	0	0	39
Dodge Charger SRT-8 2009	0	0	0	42
Dodge Charger Sedan 2012	0	0	0	41
Dodge Durango SUV 2007	0	0	0	38
Dodge Durango SUV 2012	0.03	0.02	0.03	41
Dodge Dakota Crew Cab 2010	0	0	0	45
Dodge Dakota Club Cab 2007	0	0	0	43
Dodge Journey SUV 2012	0.02	0.18	0.03	44
Dodge Ram Pickup 3500 Crew Cab 2010	0	0	0	40
Dodge Magnum Wagon 2008	0.05	0.02	0.03	42

Dodge Sprinter Cargo Van 2009	0.04	0.02	0.03	44
Dodge Ram Pickup 3500 Quad Cab 2009	0	0	0	39
Eagle Talon Hatchback 1998	0	0	0	46
Ferrari 458 Italia Convertible 2012	0	0	0	27
Ford F-150 Regular Cab 2007	0	0	0	33
Ferrari 458 Italia Coupe 2012	0	0	0	39
Ford Edge SUV 2012	0	0	0	42
Ferrari California Convertible 2012	0	0	0	39
FIAT 500 Convertible 2012	0	0	0	42
Ford E-Series Wagon Van 2012	0	0	0	43
FIAT 500 Abarth 2012	0	0	0	37
Ferrari FF Coupe 2012	0	0	0	43
Fisker Karma Sedan 2012	0	0	0	44
Ford Expedition EL SUV 2009	0.14	0.07	0.09	45
Ford Focus Sedan 2007	0	0	0	42
Ford F-450 Super Duty Crew Cab 2012	0.02	0.02	0.02	41
Ford Ranger SuperCab 2011	0	0	0	42
Ford F-150 Regular Cab 2012	0	0	0	45
Ford Freestar Minivan 2007	0	0	0	44
Geo Metro Convertible 1993	0	0	0	45
GMC Acadia SUV 2012	0	0	0	44
Ford Fiesta Sedan 2012	0.02	0.1	0.04	42
Ford Mustang Convertible 2007	0.03	0.02	0.03	44
Ford GT Coupe 2006	0	0	0	40
GMC Terrain SUV 2012	0	0	0	68
GMC Savana Van 2012	0.01	0.1	0.02	41
GMC Canyon Extended Cab 2012	0.01	0.02	0.01	42
Honda Odyssey Minivan 2007	0.04	0.3	0.07	44
GMC Yukon Hybrid SUV 2012	0	0	0	43
Honda Odyssey Minivan 2012	0	0	0	39
Honda Accord Sedan 2012	0	0	0	39
HUMMER H2 SUT Crew Cab 2009	0	0	0	38
HUMMER H3T Crew Cab 2010	0	0	0	41
Honda Accord Coupe 2012	0	0	0	42
Hyundai Elantra Touring Hatchback 2012	0	0	0	24
Hyundai Santa Fe SUV 2012	0	0	0	42

Hyundai Tucson SUV 2012	0	0	0	42
Hyundai Sonata Hybrid Sedan 2012	0	0	0	42
Hyundai Veloster Hatchback 2012	0	0	0	43
Hyundai Azera Sedan 2012	0	0	0	42
Hyundai Genesis Sedan 2012	0	0	0	33
Hyundai Elantra Sedan 2007	0.01	0.03	0.02	39
Hyundai Sonata Sedan 2012	0	0	0	43
Hyundai Accent Sedan 2012	0	0	0	41
Infiniti QX56 SUV 2011	0.01	0.14	0.02	42
Jeep Wrangler SUV 2012	0	0	0	34
Jeep Patriot SUV 2012	0	0	0	32
Infiniti G Coupe IPL 2012	0.06	0.03	0.04	40
Jeep Compass SUV 2012	0	0	0	46
Jeep Grand Cherokee SUV 2012	0.01	0.02	0.01	42
Jaguar XK XKR 2012	0	0	0	45
Hyundai Veracruz SUV 2012	0.01	0.09	0.02	44
Jeep Liberty SUV 2012	0.01	0.05	0.02	44
Isuzu Ascender SUV 2008	0	0	0	43
Lincoln Town Car Sedan 2011	0	0	0	43
Land Rover Range Rover SUV 2012	0	0	0	44
Lamborghini Reventon Coupe 2008	0.44	0.11	0.18	35
Land Rover LR2 SUV 2012	0	0	0	36
Lamborghini Gallardo LP 570-4 Superleggera 2012	0	0	0	42
Mazda Tribute SUV 2011	0	0	0	42
Lamborghini Diablo Coupe 2001	0.01	0.03	0.01	39
Lamborghini Aventador Coupe 2012	0	0	0	36
Maybach Landaulet Convertible 2012	0	0	0	29
McLaren MP4-12C Coupe 2012	0	0	0	36
Mercedes-Benz E-Class Sedan 2012	0	0	0	44
MINI Cooper Roadster Convertible 2012	0	0	0	48
Nissan Juke Hatchback 2012	0	0	0	45
Mercedes-Benz S-Class Sedan 2012	0	0	0	43
Nissan 240SX Coupe 1998	0.02	0.02	0.02	44
Mitsubishi Lancer Sedan 2012	0	0	0	36
Mercedes-Benz Sprinter Van 2012	0.1	0.15	0.12	41
Mercedes-Benz C-Class Sedan 2012	0	0	0	47

Mercedes-Benz 300-Class Convertible 1993	0.01	0.02	0.02	46
Mercedes-Benz SL-Class Coupe 2009	0	0	0	44
Rolls-Royce Ghost Sedan 2012	0	0	0	42
Nissan Leaf Hatchback 2012	0	0	0	38
Nissan NV Passenger Van 2012	0	0	0	44
Rolls-Royce Phantom Sedan 2012	0	0	0	43
Rolls-Royce Phantom Drophead Coupe Convertible 2012	0	0	0	41
Porsche Panamera Sedan 2012	0.11	0.05	0.07	38
Scion xD Hatchback 2012	0	0	0	30
Ram C-V Cargo Van Minivan 2012	0.01	0.02	0.02	44
Plymouth Neon Coupe 1999	0	0	0	41
smart fortwo Convertible 2012	0	0	0	45
Toyota Camry Sedan 2012	0	0	0	42
Toyota Corolla Sedan 2012	0	0	0	38
Tesla Model S Sedan 2012	0	0	0	46
Spyker C8 Convertible 2009	0	0	0	42
Spyker C8 Coupe 2009	0	0	0	40
Suzuki SX4 Sedan 2012	0	0	0	38
Suzuki Kizashi Sedan 2012	0	0	0	40
Toyota 4Runner SUV 2012	0	0	0	43
Suzuki SX4 Hatchback 2012	0	0	0	43
Suzuki Aerio Sedan 2007	0.11	0.03	0.04	38
Volvo XC90 SUV 2007	0.04	0.02	0.03	42
Volvo C30 Hatchback 2012	0.01	0.02	0.01	46
Volkswagen Beetle Hatchback 2012	0	0	0	43
Volvo 240 Sedan 1993	0.01	0.22	0.02	45
Volkswagen Golf Hatchback 2012	0	0	0	41
Volkswagen Golf Hatchback 1991	0	0	0	43
Toyota Sequoia SUV 2012	0	0	0	40
accuracy			0.01	8041
macro avg	0.01	0.01	0.01	8041
weighted avg	0.01	0.01	0.01	8041

Table 5.2: Classification report for ResNet

EfficientNet-B5

Classification report

Below mentioned table classification report for EfficientNet-B5 model. Overall Accuracy is 74%, Precision is 75%, recall is 74% and f1-Score is 74%. As observed in the classification report, for a few classes the number is low and the same is observed in test samples where the model is showing misclassification. The number of samples used for producing reports is 8041. In EfficientNet, the authors propose a new Scaling method called Compound Scaling.

Class	precision	recall	f1-score	support
Acura Integra Type R 2001	0.82	0.84	0.83	44
Acura RL Sedan 2012	0.87	0.75	0.8	44
Acura TL Sedan 2012	0.49	0.69	0.57	32
Acura TL Type-S 2008	0.7	0.77	0.73	43
Acura TSX Sedan 2012	0.9	0.67	0.77	42
Acura ZDX Hatchback 2012	0.82	0.57	0.68	40
AM General Hummer SUV 2000	0.67	0.72	0.69	39
Aston Martin V8 Vantage Convertible 2012	0.45	0.4	0.42	45
Aston Martin V8 Vantage Coupe 2012	0.54	0.46	0.5	41
Aston Martin Virage Convertible 2012	0.56	0.61	0.58	33
Audi 100 Sedan 1994	0.68	0.66	0.67	38
Audi 100 Wagon 1994	0.53	0.57	0.55	40
Aston Martin Virage Coupe 2012	0.6	0.62	0.61	42
Audi A5 Coupe 2012	0.52	0.8	0.63	41
Audi S4 Sedan 2007	0.72	0.79	0.76	43
Audi RS 4 Convertible 2008	0.81	0.83	0.82	36

Audi R8 Coupe 2012	0.71	0.49	0.58	45
Audi S5 Convertible 2012	0.75	0.54	0.63	39
Audi S4 Sedan 2012	0.74	0.67	0.7	42
Audi S5 Coupe 2012	0.41	0.31	0.35	42
Audi TT Hatchback 2011	0.51	0.72	0.59	46
Audi TT RS Coupe 2012	0.4	0.47	0.44	40
Audi TTS Coupe 2012	0.58	0.56	0.57	39
Bentley Continental Flying Spur Sedan 2007	0.51	0.43	0.47	42
Audi V8 Sedan 1994	0.56	0.58	0.57	43
Bentley Arnage Sedan 2009	0.8	0.8	0.8	35
Audi S6 Sedan 2011	0.64	0.88	0.74	41
Bentley Continental GT Coupe 2007	0.54	0.52	0.53	42
Bentley Continental Supersports Conv. Convertible 2012	0.52	0.56	0.54	41
Bentley Continental GT Coupe 2012	0.64	0.66	0.65	44
BMW 1 Series Convertible 2012	0.73	0.56	0.63	34
BMW 1 Series Coupe 2012	0.7	0.7	0.7	44
Bentley Mulsanne Sedan 2011	0.68	0.61	0.64	41
BMW 3 Series Sedan 2012	0.56	0.44	0.49	41
BMW 3 Series Wagon 2012	0.81	0.79	0.8	38
BMW 6 Series Convertible 2007	0.78	0.85	0.81	41
BMW M3 Coupe 2012	0.85	0.69	0.76	42
BMW M5 Sedan 2010	0.61	0.93	0.73	40
BMW M6 Convertible 2010	0.81	0.77	0.79	39
BMW ActiveHybrid 5 Sedan 2012	0.78	0.73	0.75	44
BMW X5 SUV 2007	0.46	0.52	0.49	46

BMW X3 SUV 2012	0.66	0.62	0.64	34
BMW X6 SUV 2012	0.67	0.86	0.76	36
Bugatti Veyron 16.4 Coupe 2009	0.56	0.83	0.67	35
Bugatti Veyron 16.4 Convertible 2009	0.64	0.72	0.68	32
BMW Z4 Convertible 2012	0.52	0.77	0.62	43
Buick Enclave SUV 2012	0.76	0.76	0.76	42
Buick Regal GS 2012	0.86	0.86	0.86	42
Buick Rainier SUV 2007	0.81	0.74	0.78	35
Cadillac Escalade EXT Crew Cab 2007	0.67	0.76	0.71	37
Buick Verano Sedan 2012	0.76	0.81	0.79	43
Cadillac CTS-V Sedan 2012	0.78	0.8	0.79	44
Cadillac SRX SUV 2012	0.89	0.98	0.93	41
Chevrolet Camaro Convertible 2012	0.63	0.69	0.66	45
Chevrolet Cobalt SS 2010	0.76	0.66	0.71	44
Chevrolet Avalanche Crew Cab 2012	0.87	0.66	0.75	41
Chevrolet Corvette Ron Fellows Edition Z06 2007	0.6	0.72	0.65	39
Chevrolet Corvette ZR1 2012	0.82	0.84	0.83	37
Chevrolet Corvette Convertible 2012	0.74	0.54	0.62	46
Chevrolet Express Cargo Van 2007	0.41	0.24	0.3	29
Chevrolet HHR SS 2010	0.53	0.6	0.56	35
Chevrolet Express Van 2007	0.82	0.92	0.87	36
Chevrolet Malibu Hybrid Sedan 2010	0.87	0.6	0.71	43
Chevrolet Malibu Sedan 2007	0.75	0.79	0.77	38
Chevrolet Monte Carlo Coupe 2007	0.7	0.68	0.69	44
Chevrolet Impala Sedan 2007	0.67	0.69	0.68	45

Chevrolet Silverado 1500 Classic Extended Cab 2007	0.82	0.86	0.84	42
Chevrolet Silverado 1500 Hybrid Crew Cab 2012	0.37	0.79	0.5	43
Chevrolet Silverado 1500 Extended Cab 2012	0.71	0.38	0.49	40
Chevrolet Silverado 2500HD Regular Cab 2012	0.69	0.41	0.51	44
Chevrolet Silverado 1500 Regular Cab 2012	0.63	0.58	0.6	38
Chevrolet Sonic Sedan 2012	0.87	0.77	0.82	44
Chevrolet TrailBlazer SS 2009	0.7	0.62	0.66	37
Chevrolet Tahoe Hybrid SUV 2012	0.72	0.85	0.78	40
Chevrolet Traverse SUV 2012	0.93	0.59	0.72	44
Chrysler PT Cruiser Convertible 2008	0.81	0.6	0.69	48
Chrysler Aspen SUV 2009	0.88	0.86	0.87	43
Chrysler Crossfire Convertible 2008	0.8	0.91	0.85	43
Chrysler 300 SRT-8 2010	0.91	0.87	0.89	45
Daewoo Nubira Wagon 2002	0.91	0.75	0.82	40
Chrysler Sebring Convertible 2010	0.8	0.86	0.83	37
Chrysler Town and Country Minivan 2012	0.88	0.82	0.85	45
Dodge Caliber Wagon 2007	0.68	0.64	0.66	42
Dodge Caravan Minivan 1997	0.54	0.7	0.61	40
Dodge Caliber Wagon 2012	0.85	0.91	0.88	43
Dodge Challenger SRT8 2011	0.97	0.82	0.89	39
Dodge Charger SRT-8 2009	0.74	0.62	0.68	42
Dodge Charger Sedan 2012	0.84	0.78	0.81	41

Dodge Durango SUV 2007	0.58	0.79	0.67	38
Dodge Durango SUV 2012	0.76	0.76	0.76	41
Dodge Dakota Crew Cab 2010	0.84	0.8	0.82	45
Dodge Dakota Club Cab 2007	0.86	0.86	0.86	43
Dodge Journey SUV 2012	0.97	0.8	0.88	44
Dodge Ram Pickup 3500 Crew Cab 2010	0.79	0.65	0.71	40
Dodge Magnum Wagon 2008	0.95	0.83	0.89	42
Dodge Sprinter Cargo Van 2009	0.87	0.61	0.72	44
Dodge Ram Pickup 3500 Quad Cab 2009	0.65	0.82	0.73	39
Eagle Talon Hatchback 1998	0.85	0.74	0.79	46
Ferrari 458 Italia Convertible 2012	0.86	0.93	0.89	27
Ford F-150 Regular Cab 2007	0.79	0.94	0.86	33
Ferrari 458 Italia Coupe 2012	0.66	0.79	0.72	39
Ford Edge SUV 2012	0.71	0.57	0.63	42
Ferrari California Convertible 2012	0.87	0.69	0.77	39
FIAT 500 Convertible 2012	0.69	0.74	0.71	42
Ford E-Series Wagon Van 2012	0.84	0.74	0.79	43
FIAT 500 Abarth 2012	0.97	0.92	0.94	37
Ferrari FF Coupe 2012	0.86	0.84	0.85	43
Fisker Karma Sedan 2012	0.95	0.86	0.9	44
Ford Expedition EL SUV 2009	0.81	0.67	0.73	45
Ford Focus Sedan 2007	0.86	0.9	0.88	42
Ford F-450 Super Duty Crew Cab 2012	0.85	0.95	0.9	41
Ford Ranger SuperCab 2011	0.97	0.86	0.91	42
Ford F-150 Regular Cab 2012	0.73	0.78	0.75	45

Ford Freestar Minivan 2007	0.83	0.91	0.87	44
Geo Metro Convertible 1993	0.78	0.71	0.74	45
GMC Acadia SUV 2012	0.78	0.66	0.72	44
Ford Fiesta Sedan 2012	0.8	0.79	0.8	42
Ford Mustang Convertible 2007	0.93	0.84	0.88	44
Ford GT Coupe 2006	0.64	0.8	0.71	40
GMC Terrain SUV 2012	0.75	0.82	0.78	68
GMC Savana Van 2012	0.77	0.88	0.82	41
GMC Canyon Extended Cab 2012	0.88	0.67	0.76	42
Honda Odyssey Minivan 2007	0.87	0.89	0.88	44
GMC Yukon Hybrid SUV 2012	0.72	0.77	0.74	43
Honda Odyssey Minivan 2012	0.68	0.64	0.66	39
Honda Accord Sedan 2012	0.4	0.69	0.51	39
HUMMER H2 SUT Crew Cab 2009	0.66	0.61	0.63	38
HUMMER H3T Crew Cab 2010	0.9	0.85	0.88	41
Honda Accord Coupe 2012	0.82	0.86	0.84	42
Hyundai Elantra Touring Hatchback 2012	0.81	0.71	0.76	24
Hyundai Santa Fe SUV 2012	0.72	0.67	0.69	42
Hyundai Tucson SUV 2012	0.76	0.74	0.75	42
Hyundai Sonata Hybrid Sedan 2012	0.69	0.79	0.73	42
Hyundai Veloster Hatchback 2012	0.79	0.86	0.82	43
Hyundai Azera Sedan 2012	0.86	0.88	0.87	42
Hyundai Genesis Sedan 2012	0.84	0.82	0.83	33
Hyundai Elantra Sedan 2007	0.58	0.87	0.69	39
Hyundai Sonata Sedan 2012	0.9	0.88	0.89	43

Hyundai Accent Sedan 2012	0.62	0.85	0.72	41
Infiniti QX56 SUV 2011	0.75	0.43	0.55	42
Jeep Wrangler SUV 2012	0.9	0.56	0.69	34
Jeep Patriot SUV 2012	1	0.88	0.93	32
Infiniti G Coupe IPL 2012	0.82	0.93	0.87	40
Jeep Compass SUV 2012	0.76	0.7	0.73	46
Jeep Grand Cherokee SUV 2012	0.93	0.64	0.76	42
Jaguar XK XKR 2012	0.57	0.82	0.67	45
Hyundai Veracruz SUV 2012	0.94	0.7	0.81	44
Jeep Liberty SUV 2012	0.8	0.82	0.81	44
Isuzu Ascender SUV 2008	0.95	0.88	0.92	43
Lincoln Town Car Sedan 2011	0.7	0.7	0.7	43
Land Rover Range Rover SUV 2012	0.79	0.84	0.81	44
Lamborghini Reventon Coupe 2008	0.9	0.74	0.81	35
Land Rover LR2 SUV 2012	0.76	0.81	0.78	36
Lamborghini Gallardo LP 570-4 Superleggera 2012	0.79	0.74	0.77	42
Mazda Tribute SUV 2011	0.84	0.9	0.87	42
Lamborghini Diablo Coupe 2001	0.89	0.85	0.87	39
Lamborghini Aventador Coupe 2012	0.94	0.92	0.93	36
Maybach Landaulet Convertible 2012	0.87	0.69	0.77	29
McLaren MP4-12C Coupe 2012	0.83	0.94	0.88	36
Mercedes-Benz E-Class Sedan 2012	0.78	0.91	0.84	44
MINI Cooper Roadster Convertible 2012	0.8	0.85	0.83	48

Nissan Juke Hatchback 2012	0.76	0.87	0.81	45
Mercedes-Benz S-Class Sedan 2012	0.49	0.42	0.45	43
Nissan 240SX Coupe 1998	0.66	0.84	0.74	44
Mitsubishi Lancer Sedan 2012	0.54	0.81	0.64	36
Mercedes-Benz Sprinter Van 2012	0.83	0.73	0.78	41
Mercedes-Benz C-Class Sedan 2012	0.86	0.38	0.53	47
Mercedes-Benz 300-Class Convertible 1993	0.86	0.8	0.83	46
Mercedes-Benz SL-Class Coupe 2009	0.94	0.66	0.77	44
Rolls-Royce Ghost Sedan 2012	0.85	0.95	0.9	42
Nissan Leaf Hatchback 2012	0.91	0.84	0.88	38
Nissan NV Passenger Van 2012	0.93	0.86	0.89	44
Rolls-Royce Phantom Sedan 2012	0.56	0.53	0.55	43
Rolls-Royce Phantom Drophead Coupe Convertible 2012	0.71	0.71	0.71	41
Porsche Panamera Sedan 2012	0.88	0.55	0.68	38
Scion xD Hatchback 2012	0.64	0.7	0.67	30
Ram C-V Cargo Van Minivan 2012	0.77	0.68	0.72	44
Plymouth Neon Coupe 1999	0.7	0.68	0.69	41
smart fortwo Convertible 2012	0.8	0.87	0.83	45
Toyota Camry Sedan 2012	0.8	0.67	0.73	42
Toyota Corolla Sedan 2012	0.68	0.66	0.67	38
Tesla Model S Sedan 2012	0.74	0.67	0.7	46
Spyker C8 Convertible 2009	0.67	0.81	0.73	42
Spyker C8 Coupe 2009	0.55	0.53	0.54	40

Suzuki SX4 Sedan 2012	0.71	0.76	0.73	38
Suzuki Kizashi Sedan 2012	0.88	0.9	0.89	40
Toyota 4Runner SUV 2012	0.85	0.81	0.83	43
Suzuki SX4 Hatchback 2012	0.78	0.67	0.72	43
Suzuki Aerio Sedan 2007	0.73	0.84	0.78	38
Volvo XC90 SUV 2007	0.89	0.95	0.92	42
Volvo C30 Hatchback 2012	0.7	0.85	0.76	46
Volkswagen Beetle Hatchback 2012	0.66	0.88	0.75	43
Volvo 240 Sedan 1993	0.88	0.8	0.84	45
Volkswagen Golf Hatchback 2012	0.78	0.85	0.81	41
Volkswagen Golf Hatchback 1991	0.89	0.72	0.79	43
Toyota Sequoia SUV 2012	0.95	0.95	0.95	40

accuracy			0.74	8041
macro avg	0.75	0.74	0.74	8041
weighted avg	0.75	0.74	0.74	8041

Table 5.3: Classification report for EfficientNet-B5

Efficient Net B7

Below mentioned table classification report for EfficientNet-B5 model. Overall Accuracy is 79%, Precision is 78%, recall is 78% and f1-Score is 78%. As observed in the classification report, for a few classes the number is low and the same is observed in test samples where the model is showing misclassification. The number of samples used for producing reports is 8041. In EfficientNet, the authors propose a new Scaling method called Compound Scaling.

Classification report

	precision	recall	f1-score	support
Acura Integra Type R 2001	0.89	0.95	0.92	44
Acura RL Sedan 2012	0.92	0.8	0.85	44
Acura TL Sedan 2012	0.59	0.62	0.61	32
Acura TL Type-S 2008	0.81	0.88	0.84	43
Acura TSX Sedan 2012	0.78	0.83	0.8	42
Acura ZDX Hatchback 2012	0.88	0.7	0.78	40
AM General Hummer SUV 2000	0.68	0.72	0.7	39
Aston Martin V8 Vantage Convertible 2012	0.63	0.6	0.61	45
Aston Martin V8 Vantage Coupe 2012	0.63	0.54	0.58	41
Aston Martin Virage Convertible 2012	0.68	0.64	0.66	33
Audi 100 Sedan 1994	0.74	0.82	0.78	38
Audi 100 Wagon 1994	0.68	0.57	0.62	40
Aston Martin Virage Coupe 2012	0.64	0.83	0.72	42
Audi A5 Coupe 2012	0.57	0.88	0.69	41
Audi S4 Sedan 2007	0.68	0.91	0.78	43
Audi RS 4 Convertible 2008	0.79	0.92	0.85	36
Audi R8 Coupe 2012	0.87	0.73	0.8	45
Audi S5 Convertible 2012	0.66	0.59	0.62	39
Audi S4 Sedan 2012	0.77	0.55	0.64	42
Audi S5 Coupe 2012	0.49	0.43	0.46	42
Audi TT Hatchback 2011	0.84	0.8	0.82	46
Audi TT RS Coupe 2012	0.42	0.62	0.51	40
Audi TTS Coupe 2012	0.7	0.59	0.64	39
Bentley Continental Flying Spur Sedan 2007	0.53	0.45	0.49	42
Audi V8 Sedan 1994	0.68	0.63	0.65	43
Bentley Arnage Sedan 2009	0.77	0.69	0.73	35
Audi S6 Sedan 2011	0.71	0.83	0.76	41
Bentley Continental GT Coupe 2007	0.69	0.79	0.73	42
Bentley Continental Supersports Conv. Convertible 2012	0.82	0.8	0.81	41
Bentley Continental GT Coupe 2012	0.72	0.64	0.67	44

BMW 1 Series Convertible 2012	0.85	0.68	0.75	34
BMW 1 Series Coupe 2012	0.73	0.82	0.77	44
Bentley Mulsanne Sedan 2011	0.8	0.68	0.74	41
BMW 3 Series Sedan 2012	0.61	0.49	0.54	41
BMW 3 Series Wagon 2012	0.69	0.89	0.78	38
BMW 6 Series Convertible 2007	0.86	0.78	0.82	41
BMW M3 Coupe 2012	0.71	0.76	0.74	42
BMW M5 Sedan 2010	0.74	0.88	0.8	40
BMW M6 Convertible 2010	0.76	0.87	0.81	39
BMW ActiveHybrid 5 Sedan 2012	0.71	0.82	0.76	44
BMW X5 SUV 2007	0.58	0.72	0.64	46
BMW X3 SUV 2012	0.78	0.53	0.63	34
BMW X6 SUV 2012	0.67	0.67	0.67	36
Bugatti Veyron 16.4 Coupe 2009	0.79	0.66	0.72	35
Bugatti Veyron 16.4 Convertible 2009	0.58	0.78	0.67	32
BMW Z4 Convertible 2012	0.8	0.74	0.77	43
Buick Enclave SUV 2012	0.71	0.86	0.77	42
Buick Regal GS 2012	0.9	0.86	0.88	42
Buick Rainier SUV 2007	0.81	0.74	0.78	35
Cadillac Escalade EXT Crew Cab 2007	0.72	0.84	0.77	37
Buick Verano Sedan 2012	0.85	0.93	0.89	43
Cadillac CTS-V Sedan 2012	0.93	0.86	0.89	44
Cadillac SRX SUV 2012	0.93	0.95	0.94	41
Chevrolet Camaro Convertible 2012	0.74	0.78	0.76	45
Chevrolet Cobalt SS 2010	0.74	0.77	0.76	44
Chevrolet Avalanche Crew Cab 2012	0.94	0.76	0.84	41
Chevrolet Corvette Ron Fellows Edition Z06 2007	0.66	0.69	0.68	39
Chevrolet Corvette ZR1 2012	0.8	0.97	0.88	37
Chevrolet Corvette Convertible 2012	0.94	0.74	0.83	46
Chevrolet Express Cargo Van 2007	0.36	0.17	0.23	29
Chevrolet HHR SS 2010	0.4	0.66	0.5	35
Chevrolet Express Van 2007	0.85	0.97	0.91	36

Chevrolet Malibu Hybrid Sedan 2010	0.67	0.74	0.7	43
Chevrolet Malibu Sedan 2007	0.81	0.79	0.8	38
Chevrolet Monte Carlo Coupe 2007	0.78	0.8	0.79	44
Chevrolet Impala Sedan 2007	0.87	0.76	0.81	45
Chevrolet Silverado 1500 Classic Extended Cab 2007	0.79	0.81	0.8	42
Chevrolet Silverado 1500 Hybrid Crew Cab 2012	0.73	0.84	0.78	43
Chevrolet Silverado 1500 Extended Cab 2012	0.71	0.5	0.59	40
Chevrolet Silverado 2500HD Regular Cab 2012	0.66	0.7	0.68	44
Chevrolet Silverado 1500 Regular Cab 2012	0.56	0.66	0.6	38
Chevrolet Sonic Sedan 2012	0.88	0.64	0.74	44
Chevrolet TrailBlazer SS 2009	0.74	0.7	0.72	37
Chevrolet Tahoe Hybrid SUV 2012	0.83	0.85	0.84	40
Chevrolet Traverse SUV 2012	0.88	0.68	0.77	44
Chrysler PT Cruiser Convertible 2008	0.91	0.6	0.72	48
Chrysler Aspen SUV 2009	0.87	0.91	0.89	43
Chrysler Crossfire Convertible 2008	0.88	0.88	0.88	43
Chrysler 300 SRT-8 2010	0.82	0.93	0.87	45
Daewoo Nubira Wagon 2002	0.88	0.88	0.88	40
Chrysler Sebring Convertible 2010	0.86	0.84	0.85	37
Chrysler Town and Country Minivan 2012	1	0.8	0.89	45
Dodge Caliber Wagon 2007	0.67	0.88	0.76	42
Dodge Caravan Minivan 1997	0.76	0.62	0.68	40
Dodge Caliber Wagon 2012	0.76	0.95	0.85	43
Dodge Challenger SRT8 2011	0.94	0.87	0.91	39
Dodge Charger SRT-8 2009	0.74	0.69	0.72	42
Dodge Charger Sedan 2012	0.77	0.9	0.83	41
Dodge Durango SUV 2007	0.71	0.89	0.79	38
Dodge Durango SUV 2012	0.94	0.8	0.87	41
Dodge Dakota Crew Cab 2010	0.81	0.87	0.84	45
Dodge Dakota Club Cab 2007	0.95	0.86	0.9	43

Dodge Journey SUV 2012	0.95	0.89	0.92	44
Dodge Ram Pickup 3500 Crew Cab 2010	0.85	0.88	0.86	40
Dodge Magnum Wagon 2008	0.94	0.79	0.86	42
Dodge Sprinter Cargo Van 2009	0.7	0.68	0.69	44
Dodge Ram Pickup 3500 Quad Cab 2009	0.74	0.74	0.74	39
Eagle Talon Hatchback 1998	0.9	0.78	0.84	46
Ferrari 458 Italia Convertible 2012	1	0.96	0.98	27
Ford F-150 Regular Cab 2007	0.91	0.94	0.93	33
Ferrari 458 Italia Coupe 2012	0.71	0.74	0.72	39
Ford Edge SUV 2012	0.75	0.64	0.69	42
Ferrari California Convertible 2012	0.94	0.79	0.86	39
FIAT 500 Convertible 2012	0.87	0.79	0.82	42
Ford E-Series Wagon Van 2012	0.89	0.79	0.84	43
FIAT 500 Abarth 2012	0.94	0.92	0.93	37
Ferrari FF Coupe 2012	0.91	0.93	0.92	43
Fisker Karma Sedan 2012	0.83	0.89	0.86	44
Ford Expedition EL SUV 2009	0.84	0.8	0.82	45
Ford Focus Sedan 2007	0.95	0.93	0.94	42
Ford F-450 Super Duty Crew Cab 2012	0.86	0.9	0.88	41
Ford Ranger SuperCab 2011	0.78	0.83	0.8	42
Ford F-150 Regular Cab 2012	0.84	0.82	0.83	45
Ford Freestar Minivan 2007	0.84	0.98	0.91	44
Geo Metro Convertible 1993	0.86	0.71	0.78	45
GMC Acadia SUV 2012	0.77	0.61	0.68	44
Ford Fiesta Sedan 2012	0.81	0.81	0.81	42
Ford Mustang Convertible 2007	0.88	0.82	0.85	44
Ford GT Coupe 2006	0.76	0.65	0.7	40
GMC Terrain SUV 2012	0.7	0.76	0.73	68
GMC Savana Van 2012	0.88	0.93	0.9	41
GMC Canyon Extended Cab 2012	0.85	0.69	0.76	42
Honda Odyssey Minivan 2007	0.87	0.89	0.88	44
GMC Yukon Hybrid SUV 2012	0.94	0.74	0.83	43
Honda Odyssey Minivan 2012	0.84	0.92	0.88	39
Honda Accord Sedan 2012	0.72	0.74	0.73	39

HUMMER H2 SUT Crew Cab 2009	0.63	0.71	0.67	38
HUMMER H3T Crew Cab 2010	0.92	0.85	0.89	41
Honda Accord Coupe 2012	0.76	0.93	0.84	42
Hyundai Elantra Touring Hatchback 2012	0.44	0.83	0.58	24
Hyundai Santa Fe SUV 2012	0.91	0.71	0.8	42
Hyundai Tucson SUV 2012	0.77	0.81	0.79	42
Hyundai Sonata Hybrid Sedan 2012	0.79	0.81	0.8	42
Hyundai Veloster Hatchback 2012	0.74	0.98	0.84	43
Hyundai Azera Sedan 2012	0.97	0.79	0.87	42
Hyundai Genesis Sedan 2012	0.88	0.88	0.88	33
Hyundai Elantra Sedan 2007	0.82	0.95	0.88	39
Hyundai Sonata Sedan 2012	0.72	0.91	0.8	43
Hyundai Accent Sedan 2012	0.77	0.8	0.79	41
Infiniti QX56 SUV 2011	0.9	0.43	0.58	42
Jeep Wrangler SUV 2012	0.85	0.85	0.85	34
Jeep Patriot SUV 2012	0.94	0.91	0.92	32
Infiniti G Coupe IPL 2012	0.58	0.95	0.72	40
Jeep Compass SUV 2012	0.83	0.43	0.57	46
Jeep Grand Cherokee SUV 2012	0.81	0.83	0.82	42
Jaguar XK XKR 2012	0.83	0.87	0.85	45
Hyundai Veracruz SUV 2012	0.88	0.82	0.85	44
Jeep Liberty SUV 2012	0.82	0.82	0.82	44
Isuzu Ascender SUV 2008	1	0.93	0.96	43
Lincoln Town Car Sedan 2011	0.8	0.86	0.83	43
Land Rover Range Rover SUV 2012	0.98	0.91	0.94	44
Lamborghini Reventon Coupe 2008	1	0.8	0.89	35
Land Rover LR2 SUV 2012	0.87	0.94	0.91	36
Lamborghini Gallardo LP 570-4 Superleggera 2012	0.88	0.71	0.79	42
Mazda Tribute SUV 2011	0.85	0.98	0.91	42
Lamborghini Diablo Coupe 2001	0.94	0.87	0.91	39
Lamborghini Aventador Coupe 2012	0.89	0.94	0.92	36
Maybach Landaulet Convertible 2012	0.83	0.86	0.85	29

McLaren MP4-12C Coupe 2012	0.78	0.89	0.83	36
Mercedes-Benz E-Class Sedan 2012	0.77	0.91	0.83	44
MINI Cooper Roadster Convertible 2012	0.94	0.94	0.94	48
Nissan Juke Hatchback 2012	0.79	0.93	0.86	45
Mercedes-Benz S-Class Sedan 2012	0.64	0.37	0.47	43
Nissan 240SX Coupe 1998	0.68	0.91	0.78	44
Mitsubishi Lancer Sedan 2012	0.79	0.72	0.75	36
Mercedes-Benz Sprinter Van 2012	0.75	0.8	0.78	41
Mercedes-Benz C-Class Sedan 2012	0.94	0.64	0.76	47
Mercedes-Benz 300-Class Convertible 1993	0.87	0.89	0.88	46
Mercedes-Benz SL-Class Coupe 2009	0.94	0.66	0.77	44
Rolls-Royce Ghost Sedan 2012	0.95	0.93	0.94	42
Nissan Leaf Hatchback 2012	1	0.82	0.9	38
Nissan NV Passenger Van 2012	0.91	0.89	0.9	44
Rolls-Royce Phantom Sedan 2012	0.69	0.63	0.66	43
Rolls-Royce Phantom Drophead Coupe Convertible 2012	0.78	0.68	0.73	41
Porsche Panamera Sedan 2012	0.76	0.66	0.7	38
Scion xD Hatchback 2012	0.69	0.73	0.71	30
Ram C-V Cargo Van Minivan 2012	0.59	0.66	0.62	44
Plymouth Neon Coupe 1999	0.69	0.8	0.74	41
smart fortwo Convertible 2012	0.75	0.8	0.77	45
Toyota Camry Sedan 2012	0.61	0.64	0.63	42
Toyota Corolla Sedan 2012	0.9	0.68	0.78	38
Tesla Model S Sedan 2012	0.69	0.8	0.74	46
Spyker C8 Convertible 2009	0.78	0.76	0.77	42
Spyker C8 Coupe 2009	0.62	0.57	0.6	40
Suzuki SX4 Sedan 2012	0.69	0.89	0.78	38
Suzuki Kizashi Sedan 2012	0.86	0.93	0.89	40
Toyota 4Runner SUV 2012	0.7	0.88	0.78	43
Suzuki SX4 Hatchback 2012	0.8	0.74	0.77	43
Suzuki Aerio Sedan 2007	0.81	0.79	0.8	38
Volvo XC90 SUV 2007	0.85	0.93	0.89	42

Volvo C30 Hatchback 2012	0.92	0.98	0.95	46
Volkswagen Beetle Hatchback 2012	0.85	0.77	0.8	43
Volvo 240 Sedan 1993	0.91	0.89	0.9	45
Volkswagen Golf Hatchback 2012	1	0.8	0.89	41
Volkswagen Golf Hatchback 1991	0.91	0.74	0.82	43
Toyota Sequoia SUV 2012	0.93	0.97	0.95	40

Table 5.4: Classification report for EfficientNet-B7

REFERENCES

<https://keras.io/api/applications/>

<https://arxiv.org/abs/1704.04861>

<https://arxiv.org/abs/1801.04381>

<https://arxiv.org/abs/1512.03385>

<https://keras.io/api/applications/efficientnet/#efficientnetb7-function>

<https://keras.io/api/applications/efficientnet/#efficientnetb5-function>